BEHIND THE
DOCTOR

LOGAN CLENDENING

BEHIND THE DOCTOR

With Illustrations from Contemporary Sources, Portraits, Photographs, and Original Drawings by James E. Bodrero and Ruth Harris Bohan

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TO

ELLEN HIXON GLORE

Dear Ellen:

You should have been the doctor in the family. That has been evident ever since long ago you scorned my ignorance about the care of infants and rejected the advices I proffered and quoted Gene and all the others to confuse me.

And what a grand doctor you would have been! How you would have bullied your patients! And how they would have loved it! How you would have sneered at your rivals! And got the better of them!

But the circumstances of your exalted birth and equally exalted marriage prevented any such lowly career. And to make up to you, if ever so little, for your disappointment this book about all the doctors who ever lived is yours.

A solemn book would not fit you. So I am glad it turned out to be more of a story than a sermon.

L. C.

Medicine learned "from a Jesuit how to cure agues, from a friar how to cut for the stone, from a soldier how to treat gout, from a sailor how to keep off scurvy, from a postmaster how to sound the Eustachian tube, from a dairymaid how to prevent smallpox, and from an old market-woman how to catch the itch-insect."

OLIVER WENDELL HOLMES

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INTRODUCTORY

You have a pain in the pit of your stomach — and a devilish, dirty, mean pain it is, too. It's almost more than a man can bear. You've had it all night, but you're not the one to wake anybody else up. You let the rest of them sleep and you suffered in silence. You thought the pain would go away by morning.

But now it's morning and you've still got the pain and it's worse and you want a doctor.

So the doctor comes. He looks at you in a superficial way and asks you a few questions and then he goes " Humph." And he opens the bag he has with him and takes out a thing with rubber tubing and something to stick in his ears and he listens to your heart and he says " Humph." And then he takes out a thermometer and puts it under your tongue awhile, and looks at it and goes " Humph " again. Then he counts your pulse with his watch in hand, and he prods you over the sore place and says he guesses you have gall-stones, but you'd better go to the hospital and find out for sure.

And you guess so, too! By golly, it's high time something was being done for this pain! It's worse than ever. So the doctor says: " Oh! All right," he can fix that; and he gets out a hypodermic syringe and boils some water and dissolves a little pellet, and shoots it into the skin of your arm, and pretty soon you're on your way to the hospital.

You think as you roll along in the ambulance that there is a comforting kind of air about the fellow for all his lack of sympathy. Somehow, whether it was that stuff he shot in your arm or not, the pain *is* better. How did he get to be so clever?

Well, here you are at the hospital, and here you are in bed, and a fellow has come and punctured your finger with a needle and sucked some blood out and is going to look at it under a microscope. And they took a specimen of your urine away somewhere, and they're going to exam-

ine that. And now they've given you some pills and are looking at you with the X-ray.

And then the next thing the doctor comes in and says: "Yes, it's gall-stones," and he is going to operate. And they roll you on a cart, just as if you were a bundle of hay, and take you somewhere, and a fellow says: "Any false teeth in your mouth?" and claps something over your face. Then there is a funny sweet, cold smell, and time stretches out and you are shot out of a cannon to Mars. When you wake up, a pretty girl is holding a basin for you to vomit in, and the doctor is standing by your bed holding a little bottle full of gall-stones. And they're yours, all yours. And you're glad they're out. And you decide to go to sleep.

And when you wake up, you find they have sewed you up in one place like a baseball. But over on the dresser are your gall-stones. And you feel kind of happy and peaceful. . . .

Clever fellow, that doctor. How did he know all that? How did he know so well what to do? He must be a good deal smarter than any ordinary man. A darn sight smarter than anybody else you know. Where did he learn that?

Must have learned it from somebody — medical school, or something — but where did they learn it? Eh? Medical school teachers had to learn it too!

What's behind the doctor?

Who's behind the doctor?

Behind the doctor — so many centuries, so many stories, so many people. I see them crowding around him — a great throng of old ghosts as he walks into the room. When he takes out his stethoscope to listen to your heart, there is thin, consumptive Dr. Laennec, of Paris, peering over his shoulder. When he taps your chest, another ghost — jolly, music-loving Dr. Leopold Auenbrugger, of Vienna, smiles in appreciation of his discovery living through the years. When the urine is examined, there is Dr. Richard Bright, of London, rattling his seals and ordering his carriage to take him to Russell Square to treat the great British merchants.

As your doctor dresses those stitches, I see little, old Ambroise Paré and gentle Joseph Lister behind him. Near your anæsthesia apparatus is the ghost of poor Horace Wells, who cut his radial artery from disappointment and bled to death.

Many other ghosts, too! Interesting, queer people. There is the stout figure of Benjamin Jesty among his cows, and scornful Lady Mary Montagu and her scapegrace son wearing his turban and sitting cross-legged on the floor of the British Embassy in Venice. Evil-looking Thomas Dover, a pirate, flying the Jolly Roger, and putting off in the long-boat to rescue Robinson Crusoe. William Harvey, the Englishman, sitting on the benches of the old anatomical theatre at Padua; and Andreas Vesalius, the Belgian, slinking through the dusky streets of Paris with a skeleton in his wheelbarrow.

And further back in the dim mists of the past I see strange medicine men, and bent figures digging herbs, and an old market-woman picking at her hands with a needle, and a deaf postmaster poking rubber tubes up his nose. The Marquis of Cinchona rides forth in his pride, the Peruvian sun beating on his breastplate as he trots at the head of his escort, the gold and blood-red flag of Spain carried before him. A bright-faced lad walks thoughtfully down the temple steps in far-away Greece and blinks his eyes at the sunlight glinting on the blue waters of the Ægean.

All these and thousands of others are behind the doctor. Vivid people in their day, full of hopes and interests and queer notions.

Do you want to hear some of their stories? Do you want to come with me beyond the present, back to see what is behind the doctor?

PART 1

THE BEGINNINGS

CHAPTER I

THE MEDICINE MAN

In the dawn of time on a river-bank in the green land! Caves, piles of rudely fashioned stones, skins hung to dry — the litter of humans.

Htebh stood at the cave mouth, sadly gazing at his son. The youth was in the throes of his terrible malady again.

He had felt it coming on. That was the strange thing about this demon that possessed him. It gave warnings. The boy had known the fit was coming and had staggered up to the plot of grass under the great tree. He had learned from experience that it was safer for him to be on the grass away from stones or logs.

There he lay panting now, for the fit had passed. First he had emitted a great shout — a tortured cry of agony as his head was thrown back, his arms and legs were drawn into convulsion after convulsion which racked him, his eyes turned up and the froth formed in his mouth.

The women came crowding to the mouth of the cave. Most of them gave one glance and went back to their work, for the wretched boy's attacks were a familiar sight by this time. Only his mother sat down and, covering her face with her hands, rocked herself to and fro, moaning.

One of the boy's brothers, coming up the steep slope from the river below, glanced at the quivering figure under the tree and laughed derisively. But Htebh rebuked him.

"Fool! And of a fool's litter!" he cried. "Do you wish to court devils? The fiend that inhabits thy brother may spawn and send some of his brood into thy head."

The awesome warning served to quiet the scoffer.

The grandmother came out of the cave and waddled over to the prostrate figure. Taking out of her bag a sharpened fish-bone, she grasped the lad's arm and thrust the point of the bone into one of the

veins that could be plainly seen beneath the skin. The blood flowed freely.

Htebh made no sign at this, nor any attempt to stop her. But they had tried that before. The devils which caused this malady did not flow out of the body with the blood.

Neolithic trephining. Making a hole in the skull to let the devils out.

"Go fetch the medicine man, Astur," he commanded the youth who had laughed.

By the time the priest and medicine man with his train of assistants could be seen coming up the river path, the sick boy was to all outward appearances perfectly well. His mother sat over him crooning and rubbing his forehead.

"The demon still tortures my son," Htebh announced to Astur.

The medicine man frowned portentously at this, as if to rebuke boy and demon both.

" I have tried everything," Htebh continued. " The demon resists all my magic. Do not forget that I have tried the incantation of the seven fishes, and still the demon returns. His blood has flown over and over again, and still the demon does not leave him."

" Ay," said the medicine man, solemnly, " these devils which cause convulsions inhabit the head." Here the priest tapped his forehead. " We must give them a way to get out. We must make an opening there."

Htebh nodded in agreement and acquiescence.

" Send for Achot, the trephiner," commanded the priest.

" I know these demons," explained the medicine man while they awaited the arrival of the trephiner. " When I was young, my father pointed out to me one of our tribesmen who had been in the great battle with the warriors of the Folk Beyond the East. In the battle he had been struck on the right side of the head by a spear. The spear was flung with great force and broke the bone. But on the point of that spear the medicine worker of the Folk Beyond the East had witched a demon, and it entered the head of our tribesman and he suffered as does your boy. Hy! " Here the medicine man's voice sunk to a whisper. " Do you know something else that was strange about that demon ? My father pointed it out to me and I have seen it since with my own eyes. Though the hole was in the right side of the head, it was the left arm and leg that was convulsed. These are subtle demons. They roam through all parts."

The trephiner was a man of venerable appearance. He had been brought up to do this work. His father and his father's father had been trephiners before him.

With him had come also the high priest and the headman of the tribe.

The patient was laid out on the ground. His hands and feet were bound with thongs. His head was laid on a stone.

The priest stood at his head. A circle of priests and tribesmen sat around the prostrate form. The medicine man walked round and round inside this circle chanting a religious hymn. The circle of helpers rocked back and forth emitting long-drawn wails for help.

The trephiner laid out several sharp-edged flints on a flat rock. He put some soft dried moss beside him, and, speaking gently and en-

couragingly to the boy, he made a swift cut through the skin of the scalp. He mopped the blood up with his dry moss and put his hand out for a glowing brand of wood which his assistant handed him from the fire. He seared the edges of the scalp wound, and the victim for the first time let out a long wail of pain. The incantations rose in volume.

Exposing the smooth plate of bone, the trephiner now took one of his sharp-edged flints and began to scrape the bone. The victim writhed a little from time to time, but did not complain much. It probably hurt him less than the dentist of our own day hurts one of his patients with his drill.

A priest came forward and put a cup of mistletoe wine to the boy's lips. He drank several cups during the operation, so that by the time the opening was completed, he was snoring happily.

The surgeon packed wet moss over the wound and left him sleeping in the cave. For several days he tossed with fever. Matter came running from the wound. The priest said it was the sign the devil inside was dying. Wine was poured on the wound. The old grandmother brought herbs from the woods to quiet him.

Finally he was able to be up and about. And, sure enough, the demons did not trouble him for all of that summer and the winter following and the next winter.

But then the demon returned. He had another convulsion, and the trephiner, with the help of the priest, made a hole on the opposite side of his head. For a while again there was no falling sickness, and then the boy disappeared. Search of the country-side failed to find him. Weeks later his body was found at the foot of a cliff. Probably, they said, the demon returned and attacked him as he was standing on the edge, and in his convulsion he threw himself over and was killed.

This story of mine, while it is entirely fanciful, has firm basis in reality.

Skulls with round trephine openings in them have been found in prehistoric human excavations all over the world. These holes were not made in the skull after death, because many of them show, around the edges of the opening, evidence that the bone has grown in an attempt at healing. From the same signs we decide that the trephining

did not kill the patient. Some skulls show several trephine openings of different dates — some more healed than others.

Further conviction is added by the knowledge that certain primitives still perform trephining. "Lucas Championnière saw a Kabyle thonbit who told him it was quite common among his tribe; he was the son of a family of trephiners, and had undergone the operation four times;

Prehistoric skull showing trephine openings made during life. The rounded edges of the openings show that the bone has grown after the wound was made. Thus we know they were made while the owner was living. Excavated in Peru.

his father, twelve times; he had three brothers, also experts; he did not consider it a dangerous operation. He did it most frequently for pain in the head, and occasionally for a fracture." (Osler: *Evolution of Modern Medicine.*)

Trephining, of course, is performed as one of the standard operations of modern surgery. It consists in taking a plate out of the bony dome of the skull. It is performed for various purposes. Remember that the skull is an unyielding casket for the brain — very useful because it protects perfectly this most vital of all structures. But the arrangement has its disadvantages. When disease occurs inside the skull — when, for instance, a tumour begins to grow — the vital brain substance is compressed and destroyed. The surgeon renders help in these circumstances by making an opening in the skull — trephining. This opening allows the contents to bulge and reduces the headache and other sufferings, preserves the intellect, and prolongs life. Sometimes through such openings it is possible to remove the tumour or loosen adhesions which are causing trouble.

This primitive operation of trephining represents one of the first upward steps we can discern in the development of scientific medicine.

Before that, all explanation of disease was magic. Devils had entered the sick man's body.

The cure for this was exorcism — driving the devils out by incantation. Ceremonies of exorcism — sometimes a ritual dance, sometimes a personal service of prayer, fast, and confession — were performed by the medicine man.

The most primitive human community may be compared to a unicellular animal. There was no specialization, no division of work. Just as the primitive animal, a single cell, takes on all the functions of the body — it digests, moves, reacts, excretes, etc. — so the primitive family did all the work of a complex society — growing edible plants, fishing, hunting, making clothes and pots, house-building, herding, defending, etc. When specialization began, it was by the formation of a caste — the priestly caste, which at first included the functions of king, judge, and medicine man, as well as priest.

The reason for the formation of just this caste, which seems to us the least important branch of practical business, is to be found in the leaning of the primitive mind towards a mystical explanation for the

Annual ceremony of the Pawnee medicine men. Among the Pawnees the medicine men ranked next to the chiefs and priests. The medicine men in this picture are dressed as various animals which are conceived of as being evil spirits. (From a miniature group in the Field Museum of Natural History, Chicago, by permission of the Curator)

universe. The priest, the medicine man, could influence unseen powers which brought rain for the crops, could prevent cataclysms of nature, such as floods, earthquakes, and volcanoes, and could also bring and take away disease.

To perform this work the medicine man was especially selected. Usually he was marked out from birth. In Liberia twins are regarded as particularly gifted. Seventh sons, as is well known, are attuned to the whisperings of the infinite. And, of course, the seventh son of a seventh son is doubly dyed. One such, a fiery old fellow, in the Highlands of Scotland, who was a militant atheist, was nevertheless up to a few years ago constantly besieged by his neighbours and even awakened in the dead of night to touch sick people brought to his door.

Babies who come into the world feet first are adept at setting fractures and curing lumbago. Those who have fits, trances, convulsions, dreams, or nightmares are obviously the tabernacles of divine visitation.

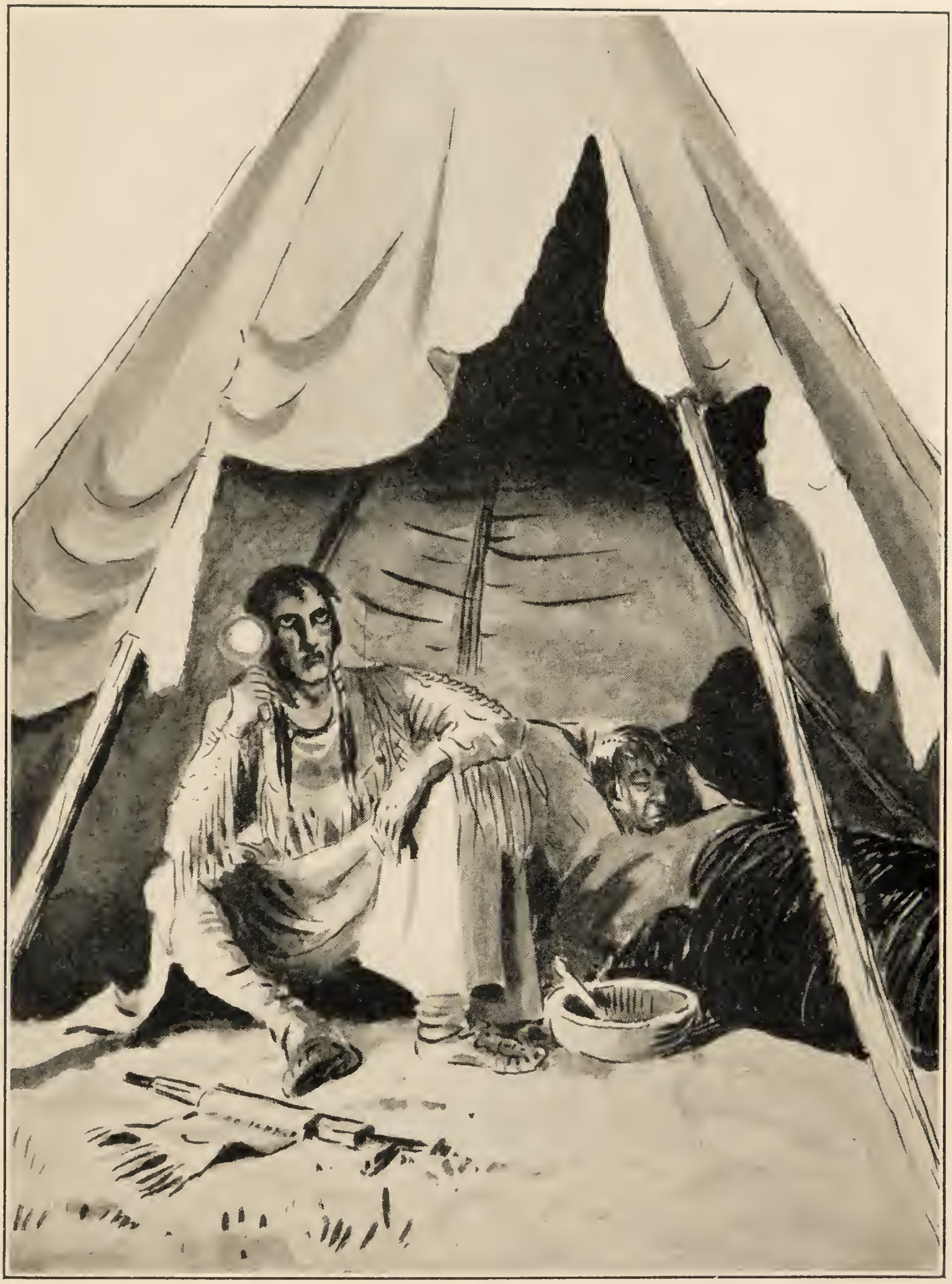
The *king* touches for the king's evil. " The king's evil " was scrofula, which is tuberculosis of the lymph nodes of the neck. These nodes swell up, however, from many causes — simple tonsillitis, for instance — and after the acute infection is reduced, the swelling of the glands goes down. It was probably this type of the disease which responded to the magic of the royal touch, although even tuberculosis of the nodes subsides spontaneously. There is no necessity, therefore, to doubt that the touch often resulted in cures.

Guilbert, Abbé de Nogent (1053–1124), described the disease thus:

" How is it that our Sovereign King Louis works this wonder repeatedly before our eyes? I have seen those afflicted with scrofulous swellings about the throat or in other parts of their bodies flock in crowds to receive his touch."

The English kings from the time of Edward the Confessor touched regularly. Queen Elizabeth seems to have had some doubts of her power and for a time discontinued the practice. " Would, would that I could give you help and succour! " she cried to the crowds of sick who pressed about her during one of her progresses through Gloucestershire. " God, God is the best and greatest physician of all; He, He is Jehovah, wise and holy, and He will relieve your sickness; to Him you must pray."

But these agnosticisms were regarded with sneering triumph by the



Exorcism. Driving out the disease demon.

priests of the Church of Rome. " She soon quitted that Fit of Puritanisme," writes Dr. Stubbe of Stratford-on-Avon, " when the Papists defamed her, as if God had withdrawn from her the gift of Healing, in that manner because she had withdrawn herself from the Roman Church."

The office for the ceremony of touching for the king's evil was included in the Book of Common Prayer. In connexion with the ceremony the sovereign always gave the afflicted patient a coin, known as

Edward the Confessor touching for the evil. From L'Estoire de Seint Edward le Rei, *MS. Ee, iii. 59 (University Library, Cambridge)*

a touch piece. Usually it was specially coined, of bronze or silver or gold, of the value of an angel (ten shillings). Those now in existence in museums are usually pierced, for the patient wore the touch piece around the neck.

William III was openly contemptuous of the royal touch. "It is a silly superstition," he said. " Give the poor creatures some money and send them away." When forced into the position once of laying his

The Manner of His Majesties Curing the Disease
CALLED THE
KINGS-EVIL.

Broadside showing ceremony of touching for the evil. Charles II. From The King's Evil, *by Raymond Crawfurd. Oxford Press.*

hand on a rich man, he said: "God give you better health and more sense."

The house of Hanover carried the note of skepticism to its final point. George I declined to touch the child of an English gentleman and with

THE

CEREMONIES

OF BLESSING

CRAMP-RINGS

On GOOD-FRIDAY,

Uſed by the

CATHOLICK KINGS

Of ENGLAND.

The pſalme Deus miſereatur noſtri, &c. with the Gloria Patri.

MAY God take pity upon us, and bleſſe us* may he ſend forth the light of his face upon us, and take pity on us.

That we may know thy ways on earth* among all nations thy ſalvation.

May people acknowledge thee, O God: * may all people acknowledge thee.

Let nations reioice, and be glad, becauſe thou iudgeſt people with equity,* and doeſt guide nations on the earth.

May people acknowledge thee, O God, may all people acknowledge thee,* the earth has ſent forth her fruit.

May

Form of prayer used by the kings of England to bless cramp-rings. These rings were supposed to protect the wearer from epilepsy. The ceremony was celebrated as late as the eighteenth century.

great good humour referred him to the exiled Stuart pretender, who indeed was sought after all his life for this purpose and who touched frequently.

As late as 1838 Pettigrew reports that a few crowns and half-crowns bearing the image and superscription of Charles I were used in the Shetland Islands as remedies for scrofula. They had been handed down from the days of the "touching."

So much for ancient and relatively modern examples of exorcism.

The evil eye. The woman makes the protective gesture against the influence of the evil eye with her hand — the imitation of a pair of horns on which to spit the diabolical force. See notes.

Another branch of magic, which may be called witchcraft, supposes that it is possible for one person to "send" disease upon another.

A simple form of witchcraft lies in the theory of the effigy. If a savage makes an effigy of a man, he somehow controls that man's mana. All primitive people object violently to being photographed or painted.

Magical law says that their images are themselves. An Ojibway medicine man will construct a wooden doll — an image of his petitioner's enemy — and run a needle into the eye or heart: then the enemy will go blind or die of heart pangs.

Any part of the body must be kept out of the hands of an enemy: hair, nail parings, fæcal matter, even clothes or soil in which are bare footprints. For the enemy will use these in lieu of the body itself and work destruction. The Victorian Blacks burn an enemy's cast-off hair and cause fever. In Scotland up to thirty years ago to burn fæces caused dysentery.

Even the enemy's name is an effigy. The curse which you just breathed against the county assessor is a witness of your belief in the power of "sending" disease.

Human beings may possess the power to confer disease and misfortune, as witness the evil eye.

Just as the treatment for demoniacal possession was exorcism, so the prevention of witchcraft was a charm.

To ward off the evil eye, raise the hand with the middle fingers closed.

Amulets, talismans, cryptic writings! There is the story of a youth at Oxford who went out into the fields and sat beneath a tree to study. Idly he traced some Greek letters upon a sheet of paper — one lovely phrase that caught his fancy. Idly he fell asleep, and when he woke, the twilight was grey about him. A young girl — a country lass — had been watching him and shyly asked for the paper on which the Greek words were written. He gave it to her and, gathering up his books, strolled back to his study. And time went on and he left Oxford. He succeeded in his work and was made a judge. One day he was presiding at Oxford and they brought before him a miserable old woman, accused of being a witch. The country-folk said she charmed the cattle with a paper on which was cabbalistic writing. The judge asked to see it, and they passed it up to him. Dimly the old man seemed to remember something familiar. Then suddenly it came to him: the so potent charm was that chorus ending from Euripides which he had scribbled and left beneath the grey towers of Oxford long ago when all the world was young.

Of other charms and healing ways:

Iron is widely regarded as having specially valuable properties:

"Let the superstitious wife
Near the child's head lay a knife,
Point be up and haft be downe
While she gossips in the towne
This 'mong other mystic charms
Keep the sleeping child from harms."

Stones. — Mad stones are still used for the bite of a mad dog. The milpreve is a blue stone supposed to be concentrated crystallized snake-venom. In the west of England they are hung around the necks of cattle to prevent the bites of adders. If one gets a stone from the stomach or gall-bladder of an animal (a bezoar stone), it is naturally more powerful than any ordinary stone.

Rings, bands, belts, and necklaces. — Constriction cures are everywhere practised. Rheumatism rings are an example. In Derbyshire a red thread is tied around the neck to prevent goitre. In Los Angeles an "electric" belt worn about the waist produces sexual virility.

Healing wells and waters. — Though largely used for skin troubles and eye diseases, the use of running water or spring water is not confined to those maladies exclusively.

"Now, there is at Jerusalem by the sheep market a pool, which is called in the Hebrew tongue Bethesda, having five porches. In these lay a great multitude of impotent folk, of blind, halt, withered, waiting for the moving of the water. For an angel went down at a certain season into the pool and troubled the water; whosoever then first after the troubling of the water stepped in was made whole of whatsoever disease he had." (John v. 2–4.)

Spittle. — "Everybody has heard of cures by saliva. . . . Warts, contracted sinews, wounds, sores, and skin-rashes in general, are to this day treated by the application of saliva, that secreted in the morning before breakfast being considered the most efficacious. . . .

"When a Dyak of Borneo is seized with vomiting and sweating he thinks that an unfriendly ancestral spirit has chased out his soul and has taken its place. So he sends for a wise woman . . . and after she has identified the intruding spirit . . . an effigy is moulded from the ashes of the hearth, and . . . the wise woman moves it seven times up and down before the patient. Then the patient spits upon the image, and the disease is thereby transferred to the spirit via his effigy." (Dan McKenzie: *The Infancy of Medicine.*)

"In Ireland, fasting spittle is considered of great efficacy by the peasants for sore eyes, especially if mixed with clay taken from a holy well. This is made into a paste and applied to the eyes." (Lady Wilde: *Ancient Cures of Ireland.* London, 1890.)

Transference of disease to animals. — "Frog in the throat" is a disease of Cheshire which is treated by holding the head of a frog in the child's mouth for a few moments; the disease passes into the animal.

The orthodox method of curing abdominal cramps is to hold a live animal on the belly. For gripes, according to Marcellus (A.D. 300), a live duck was applied to the abdomen, and the pains passed into the duck, "to whom they prove fatal."

Goitre can be transferred to a corpse, by having the hand of the corpse (especially of a young child or a suicide) touch the enlarged thyroid nine times. A young woman was led on the scaffold of Old Bailey in order to get rid of a wen by having it touched by the hand of the man just executed. In Northampton patients used to congregate around the gallows in order to receive the "dead stroke." The fee went to the hangman.

To be cured of a particularly obstinate venereal disease the patient must have intercourse with a *virgo intacta,* the disease being entirely transferred to the second person. This idea accounts for most of the cases of rape of young white girls by ignorant Negroes.

Scourging and whipping. — "In case a man be lunatic, take skin of a mere swine, work it into and whip and swinge the man therewith: soon he will be well." (Saxon Leechdoms.)

The Quixos Indians treat illness by whipping the patient with nettles.

Compared with such things, trephining was a sheer intellectual leap.

The devil was still the cause of the disease. But they had located the devil. The symptoms of epilepsy or headache or insanity were those belonging to the head. The devil who caused this sort of mischief was in the skull. Therefore, make a hole there to drive him out.

It was the beginning of reason.

CHAPTER II

EMPIRICISM AND THE WRITTEN RECORD

The milkmaid rinsed her pails with scalding water to keep the milk from souring. She didn't know why she did it. She didn't know anything about germs souring milk, and scalding water killing germs. But she knew the scalding water kept the milk from souring.

The Egyptian fisherman knew that castor-oil beans made his bowels move when he ate them. He knew nothing about the structure of the intestines — smooth muscle, peristalsis. But he knew about the beans.

That is empiricism.

Empiricism is the use of experience. It may be unexplained experience. You do not have to know why the thing works, but only to realize that it does. Empiricism developed side by side with magic.

In the realm of disease certain occurrences obviously did not need to be explained by magic. One was childbirth. One was running a thorn into the foot, or getting burned. Primitive people did not always call in medicine men to treat these things — only experienced and skilful fellow-creatures. Childbirth was handled by midwives; accidents and injuries by surgeons. Herbs were employed for a number of purposes — to heal wounds, for catharsis, to induce sleep.

Of course, admittedly, with all of this, an incrustation of magic was possible and likely. Primitive people did not understand clearly the connexion between childbirth and sexual intercourse. When this was perceived, they were likely to flatter themselves with fairy-stories of gods impregnating human women. The thorn might have been placed by an enemy or a devil so as to penetrate the toe. The herbs were always fraught with awe. But empiricism, under any circumstances, was a step upward.

The use of herbs is a good example of empiricism. When a dog is sick, he eats grass indiscriminately. So did the most primitive savage when he was sick. But there came a time when he began to seek one single herb or root or bark for a particular disease.

This mental process was not superstition. The brooding savage recognized certain symptoms. Then, from experience, he found that one herb, or combination of herbs, was pre-eminently best for this disease. Recognition of the specific element in a mass of useless ones! Classification, experience, selection, application — men who used these methods were emerging from the fog.

To illustrate, we must imagine another scene:

The year is 1638. The place the vice-regal palace of the Spanish Governor at Lima, Peru.

The Count of Cinchona, Royal Governor for His Catholic Majesty, paces to and fro over the stone courtyard of his patio. He is sad and anxious. His young wife, the beautiful Countess, is sick to the point of death. She has but lately come to this strange land from her native Spain, and the climate has not agreed with her.

One day she will seem well, and the next a sudden shaking fit and cold sweat will seize her. After it leaves, she burns with fever and tosses restlessly on her bed. She has lost weight and strength so that she is but a shadow of her former self.

The priests and the physicians have done what they could. Prayers have been offered in the cathedral for her recovery. But no sign of improvement has occurred.

The Count is waiting for the arrival of an Indian medicine man. The Countess's Indian servant has begged him to use a native remedy. He had not much hope or faith in the tales he has heard of the man until his friend the Corregidor of Loxa told him that the same remedy had been used with success in his own person the year before. And the situation is too desperate for him to refuse aid, no matter from what source.

The Indian is brought before him and solemnly acknowledges his rank with a haughty bow.

"They tell me that you have a magic which will kill the demon of fever," says the Governor.

The Indian points towards the south.

"My fathers and their fathers before them have used the god of the bark of the sacred tree quinaquina to exorcize the demon of fire."

"How did you learn of its value?" the Count demands.

"My fathers watched lions eat the bark when they were sick," answered the Indian. "Then long ago the Gods sent a great shaking of the earth here. Trees fell. They crashed into a lake, and their bark coloured the waters. And when those shaken by the demon of fire drank of the water of this lake, they were cured."

Fresco from the dispensary of the Hospital de Santo Spirito in Rome, depicting the Countess of Cinchona receiving a cup containing cinchona bark. The fresco bears the inscription:

"Ægrotat Limæ coniux Chinconia febrim
Cortice mirando pocula tincta fugant."

(The Countess of Cinchona lies sick at Lima; the cup with the wonderful cinchona tincture expels the fever.)

(Reproduced by permission of the Missouri Botanical Gardens)

There is something impressive and faith-inspiring in the man's manner.

The Jesuit priest who has come in with him now speaks.

"Are you willing to supply His Excellency some of this bark for the cure of his ailing wife?"

The Indian's eyes flash fire.

" If the father Governor will free the men of my tribe from the mita, I will drive out the demon of fire with the sacred bark."

The Spaniards have imposed forced labour in the mines on the Indians. The group so enslaved is called the mita.

The Count of Cinchona looks at the Jesuit, who shrugs his shoulders as much as to say it is quite all right to promise an Indian anything; one need not keep the letter of the promise.

" As you say," the Count gravely agrees to the Indian's terms.

The Indian turns and walks out of the palace, across the sunburnt square, and presently returns with several small pottery vessels in each of which is a small heap of bits of bark from some tree.

He is brought into the presence of the Countess, and, placing his bowls on the floor, he stands over them and chants an incantation to the sun. He pours water over the bark and stirs it for some hours. This finished, he directs the attendants to have the Countess drink the mixture from one of the bowls.

The pretty, young Countess makes a wry face as she finds how bitter the bark-mixture is, and the Indian priest smiles gravely. She is to swallow the contents of a bowl morning and evening.

The next day there is great excitement in the palace. The time when the Countess usually has her shaking fit has passed with no return of the malady. Nor has her fever risen. She continues using the bark of the sacred tree, and in a week she is carried to the patio to eat a meal with her husband.

It occurs to the Jesuit priest that this bark will be good for all fevers. He sends some people to gather quantities of it and uses it on all occasions. He sends it to Spain and Italy and everywhere that his order thrives. It is known as " Jesuits' bark." Sometimes it is called " cinchona bark " or " quinine."

The use of quinine in malaria is, of course, perfectly rational. The quinine actually kills the plasmodia which cause malaria. The Peruvian Indians who used it did not know that. Nor did the Spaniards and Jesuits who popularized its use. The idea that this fever was caused by a small animal in the blood did not arise for two hundred and fifty years. But the Peruvian Indians made the solid observation that when a certain kind of fever came on, the use of the bark from a certain tree cured it. It was one of the momentous intellectual advances of the race.

The fact that they explained it by attributing the properties of a god

to the bark, and the properties of a devil to the fever, simply is an illustration of how primitive man's thought went — rational observation and divine explanation hand in hand. It still does.

Man's preoccupation with the ills of his own flesh is attested by the fact that the oldest books in the world are medical treatises. Mr. Cyril P. Bryan, who translated into English the Egyptian papyrus which was

Specimens of cinchona bark, from which quinine is made.

found between the legs of a mummy at Thebes in 1872 and sold to the German archæologist Georg Ebers (thus known as the "Papyrus Ebers"), claims for it the title of the Most Ancient of Books — not the most ancient of the papyri, nor the most ancient of writings, but the most ancient writing elaborate and connected enough to be called a book.

There are extant six Egyptian papyri dealing with medical subjects. The Edwin Smith Papyrus is the oldest. It is dated about 3000 B.C. The Kohm Papyrus, which is fragmentary, deals mostly with diseases of women, and dates from around 1800–2000 B.C. The Ebers Papyrus dates from about 1500 B.C. The Hearst Papyrus, discovered in 1899, is of about the same date as the Ebers Papyrus, and its contents are similar. The Berlin Medical Papyrus is later in date than either the Ebers or the Hearst papyri. Its text is quite corrupt. The London Medical Papyrus, now in the British Museum, contains no material of consequence not in the other documents, although it is said to contain a larger proportion of magical matter.

Study of these writings teaches us much of the medical lore of the Egyptian cradle of civilization.

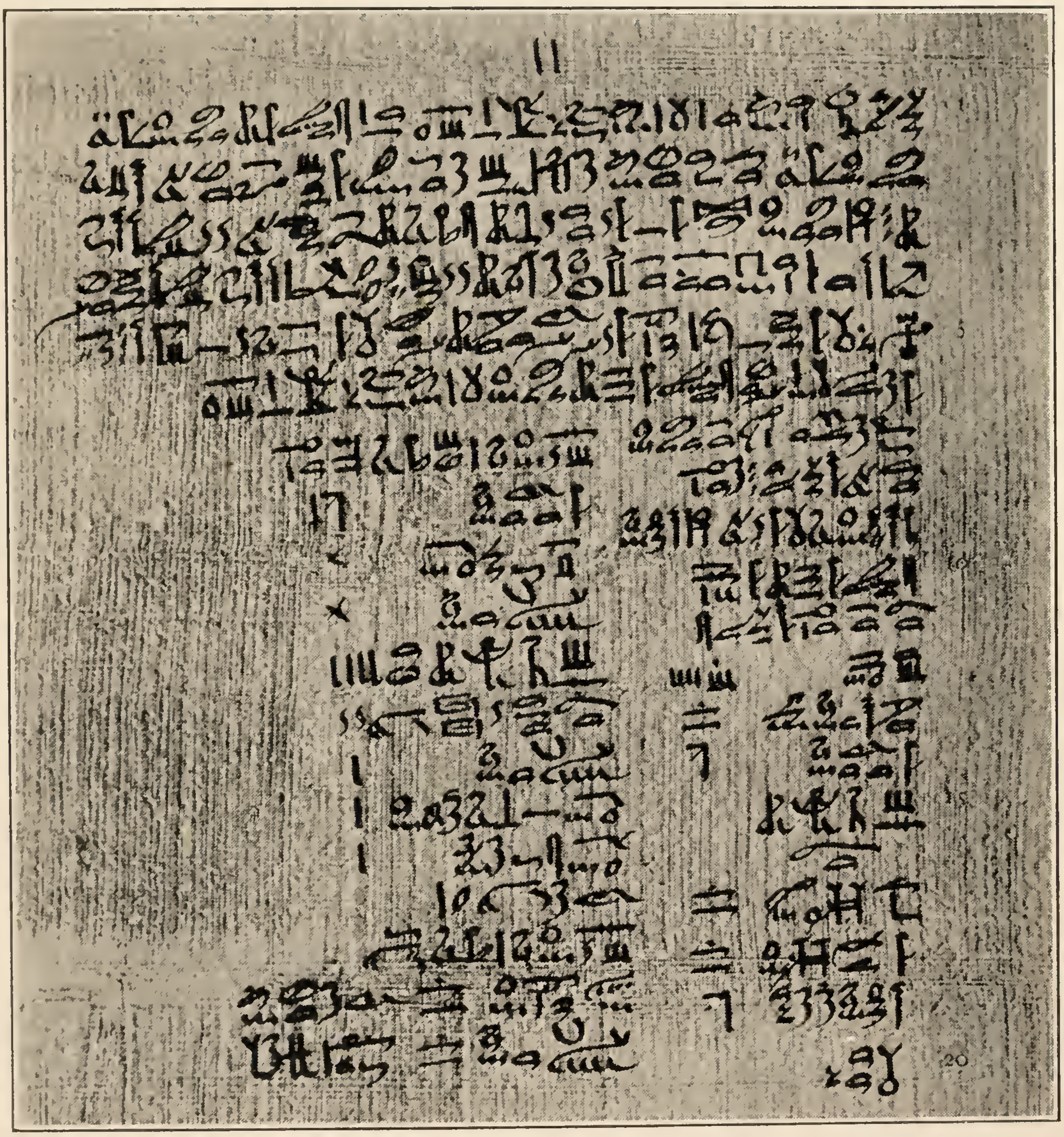
Magic was by no means unknown in Egyptian medical practice. The Egyptian divinity of the art of healing, Imhotep, who corresponded in a general way to the Grecian Æsculapius, sponsored magic. But in spite of references to ghostly intervention, which are abundant in the papyri, their general tone is rational. In other words, they assume that disease and the remedies for it operate under the sway of natural laws.

The Smith Papyrus deals with surgical subjects. A typical case (abridged) is as follows:

> "Title: Instructions concerning a gaping wound in his head smashing his skull.
>
> "Examination: If thou examinest a man having a gaping wound in his head, penetrating to the bone, [and] smashing his skull; thou shouldst palpate his wound.
>
> "Treatment: Thou shalt not bind him, [but] moor [him] at his mooring stakes, until the period of his injury passes by.
>
> "As for 'moor [him] at his mooring stakes,' it means putting him on his customary diet, without administering to him a prescription."

Both the discussion of symptoms and treatment in the Smith Papyrus are remarkable for their modern note. Approximation of the lips of an incised wound by strips of tape, apparently like adhesive plaster, is described. Sutures to approximate the edges of wounds are recommended. The reduction of a dislocation of the jaw — "thou shouldst

put thy thumbs upon the ends of the two rami of the mandible in the inside of his mouth and thy two claws [two groups of fingers] under his chin and thou shouldst cause them to fall back so they rest in their places" — is, according to an eminent surgeon of our day, Charles A. Elsberg, the same as that in use in modern times.



A page of the Papyrus Ebers. The lower part is a prescription; it originates the tradition for illegibility.

The Ebers Papyrus contains medical remedies — herbs, mineral waters, and animal parts (just as we use a part of the animal — the liver — in treating pernicious anæmia today). There are accounts, almost side by side, of the treatment of the bite of a crocodile, falling of the womb, toothache, and baldness.

The idea that constipation is " a scourge of the modern world brought about by modern conditions of living and eating " is dispelled by the appalling array of purgative prescriptions, the best being: " berries of the castor-oil trees: chew and swallow down with beer in order to clear out all that is in the body."

CHAPTER III

HIPPOCRATES, THE GREEK — THE END OF MAGIC

Philiscus, who lived by the wall in Athens, lay sick of a fever. The year, according to our reckoning, was 410 B.C. The Battle of Marathon had been fought eighty years before. Athens was still the greatest city in the world — great in the sunset of its golden age.

The members of Philiscus' family were uneasy about him, for the malady had not progressed favourably.

They sat sadly on the doorstep awaiting the report of his wife, who had gone in to help him.

She appeared with an unhappy frown on her brow.

"He doth not know me," she explained. "And he hath not slept. He hath passed water that is black." [1]

"Ah! I have seen that," exclaimed her father. "It is a bad omen." His voice sank to a whisper. "I tell you it is the hounds of Hekate that rend him."

Another elder shook his head.

"It was a sudden affliction that seized him — it came from Pan, or, mayhap, one of the arrows of Apollo," he averred.

"What physicians have treated him?" inquired this sage, after an interval of silence.

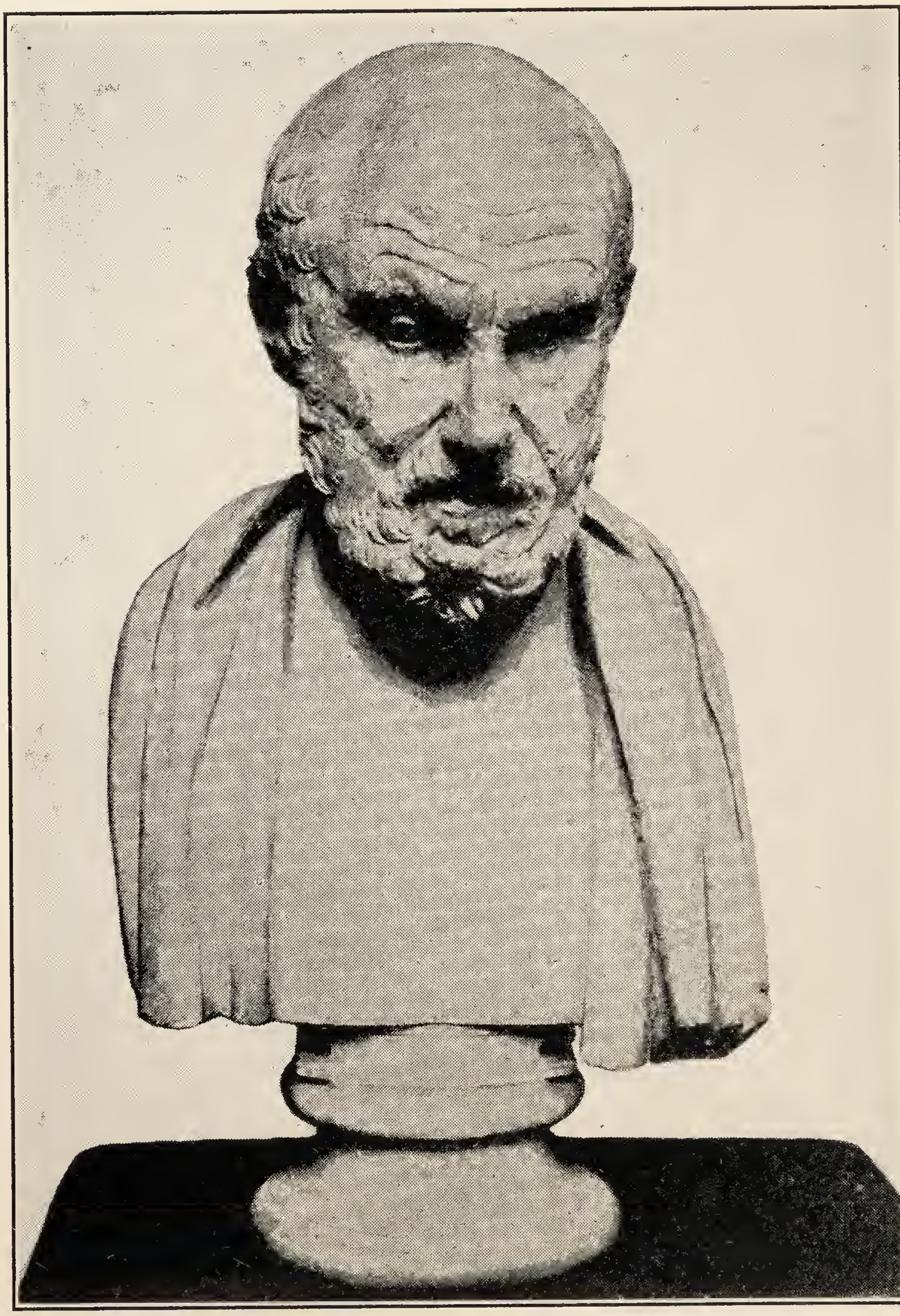
"Im-Ram, the Egyptian, came by two days ago and gave him an emetic of white hellebore. But he was no better."

The elder looked stolidly ahead at this. He did not approve of Egyptians or Egyptian remedies. He wanted to placate the angry Apollo.

[1] Black urine — due to the presence of blood — occurs in severe cases of malaria, called "black-water fever."

"Then there was the Babylonian, Mother," the son of Philiscus reminded her.

"What did he do?" inquired the elder.



Hippocrates, the Father of Medicine.

"He sacrificed a goat and made divination by the liver."

"Ah! and what did that show?" asked the elder, somewhat more approvingly.

"He laid the liver out and explained it to me carefully," said the son,

eagerly. "There was the lobus dexter and the lobus sinister — and they were inequal."

"The omens were not clear," sighed the wife.

"And the vesica fellas," continued the lad — "the gall-bladder — it was full of stones."

"How many?" demanded the old man.

"There were three large ones and many small ones."

"Three?" the elder shook his head, dubiously — "that is grave. One element is missing. There should be four."

"Water, perhaps," suggested the wife, "he cries, when he cries sensibly at all, always for water."

"Fire, air, earth, and water," repeated the old man, sententiously. "The elements of Pythagoras, the Samian. If one is taken away by the demons or the hounds of Hekate, it must be replaced. Now here the sick man is hot and dry — fire is in the ascendancy. Water is cold and moist — just the opposite. It is water he must have." And he nodded his head emphatically, pleased with his own reasoning.

"I give him water morning, noon, and night, every hour," answered the wife, distractedly.

"If we could take him to a temple of Æsculapius," suggested the father-in-law, "and let the priests treat him."

The wife shook her head. "He is too sick to move," she said, "and out of his senses — we could not leave him alone."

"I went to a temple once when I was a young man — for this eye," the old man said, reminiscently. "It was a very good temple, and a very good treatment, to my way of thought. My eye got better soon after; whereas before, it had been painful and running like a sore."

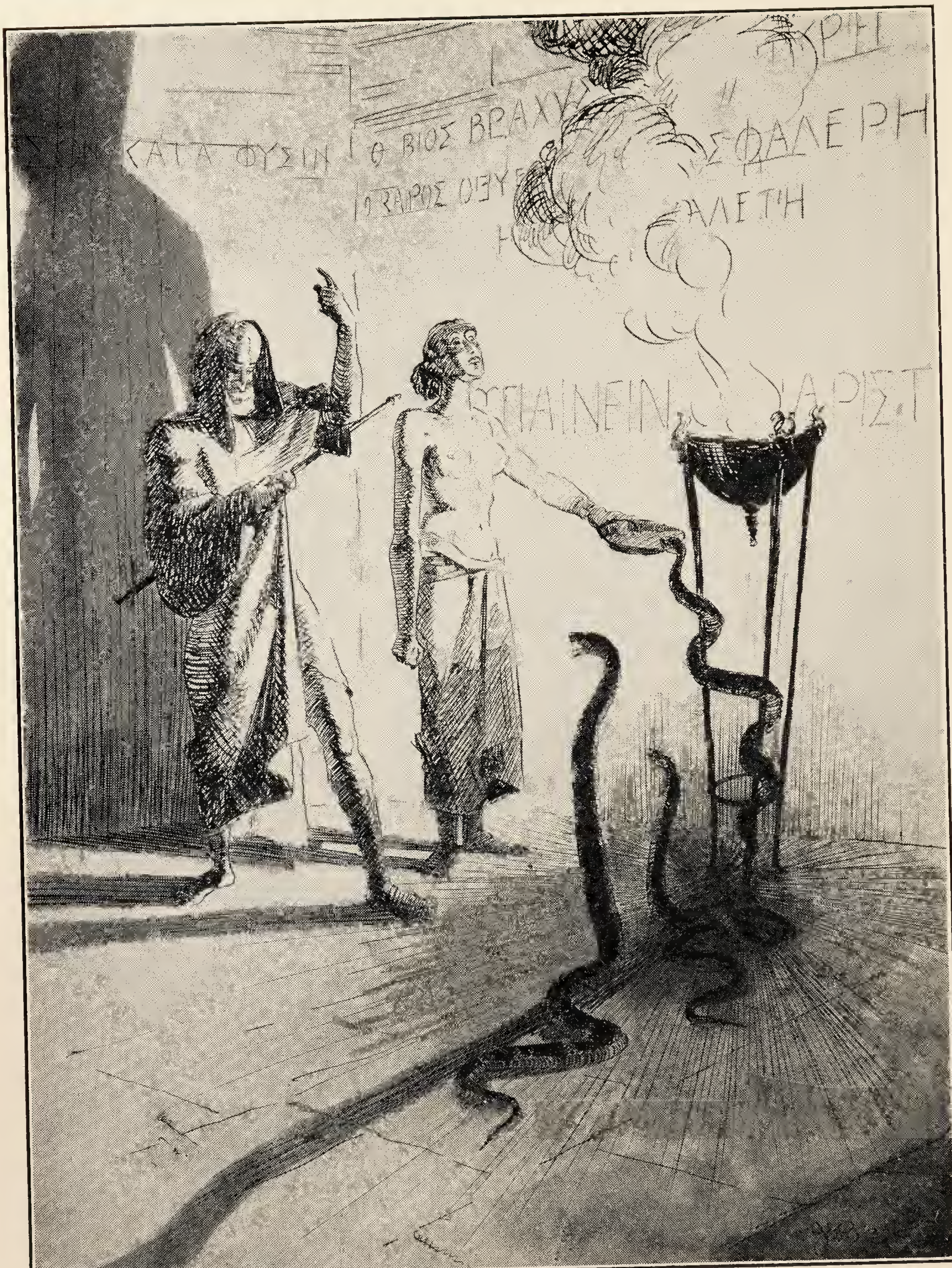
"What temple did you go to?" the other old man inquired.

"At Epidaurus[1] — naturally," the narrator replied. "I remember it very well. The priests of the temple made me cleanse myself first. There was a bath of salt water, too, as well as the clear water which they made me enter. Then I purified my soul with prayer. And then the oblation."

"What was your oblation?"

"I was too poor to offer a sheep or a cock, so I offered a popana — a small cake dipped in oil. The priests sell it to you. Then I starved four days and was allowed to enter the sanctuary for the incubation sleep."

[1] The Hieron of Epidaurus was only a few miles from Athens.



Rites in a temple of Æsculapius. Feeding the sacred serpents. (*After Caton* — British Medical Journal)

" What was that ? " asked the boy.

" Inside the temple — you slept. There was the great image of Æsculapius at the high altar. It was an awe-inspiring sight. The representation of the flesh was of ivory, and the rest was of gold enamelled in colours."

By this time he had acquired the attention of his audience, and he launched into his narrative.

Votive offering, placed in the temple of Æsculapius. This one was offered by a patient who had been cured of a disease of the eyes.

" Sufferers were all over the floor of the temple. Each of us had his pallet. The night came down and we composed ourselves to sleep. And whether it was a dream or not I cannot tell, but it seemed to me the god himself came down from the altar and walked among us. He had two great yellow snakes and a dog. He stopped a moment at my pallet and leaned over me. One of the snakes licked my eye. The god put some ointment in it. And the next day I found a box of ointment at

my side. I took it away with me. And soon my eye was well, and I placed a votive tablet in the temple."

The youth laughed incredulously.

"Ay!" the elder reproved, "in this age of doubt you fall away from the old things, but I tell you they were good — those temple rites. I know of things wrought there that would outdo your modern treatments. While I was being cured, Proklos, the philosopher, himself, was also there: he was afflicted with a rheum of his knee — very painful: and he covered it with a cloth. The night he slept in the temple, a sacred sparrow plucked the cloth away, and the pain left with it. His knee was as good as ever."

This account of success seemed to impress his audience.

"Yes, you doubt!" he continued. "You doubt the old ways, and you doubt the old gods. I heard of a new drama of Aristophanes — what is the name of it — *Plutus* — played in the theatre of Dionysus — and what does it amount to? Making fun of a poor sick person who goes to the temple for help — that's what. It jests at the priests — says they steal the offerings of food brought by the patients and eat the food themselves and give it to the sacred serpents — and all this —" the old man's voice rose excitedly — "all this played out in the theatre of Dionysus — and the priests do not interfere. Why, in my time —"

A wild cry from the delirious patient interrupted the discourse. The wife hurried in to attend her patient.

The boy crept to his grandfather's feet and said: "Grandfather, can we not fetch the physician Hippocrates to counsel about father?"

"Hippocrates? Yes, I have heard of this healer," assented his grandfather. "He hath a good name and is highly esteemed."

"He is in Athens now," declared the youth.

"He was the son of a temple priest — I know, I have heard," said the other old man. "His father was a priest in the Temple of Æsculapius at Cos. Ah, that is a wonderful temple for healing! If we cannot take Philiscus to a temple, the next best thing were to have a priest of the Asclepiadæ come to him."

The wife returned to their circle again, gravely troubled.

"He is worse even than before," she answered their interrogatory glances.

"Think you we could get Hippocrates, the physician, to see him?" asked her father.

A look of hope came to her face.

"I have heard of that Hippocrates," she answered. "Is he not the one who treated the Clazomenian who was lodged by the wall of Phynichides?"

"Yes, that was he — now that you recall it to me."

"The Clazomenian was cured."

"He was indeed — and his case is much like that of Philiscus. He had a pain in the neck and head, and fever. And he could not sleep, and besides, like Philiscus, he became delirious. He was sick for many days, but this Hippocrates came to see him every day and wrote down on his tablets the condition of the patient every day."

"What was his treatment?" asked the elder.

"That I cannot recall, but he prescribes diets and baths, that I know."

"Mayhap he leaves the patient and propitiates a god," suggested the elder.

"Mayhap, but his method was good in the case of the Clazomenian."

"Let us send for him quickly — quickly," cried the wife. "Who will help us?"

"I will run through the streets, Mother, and bring him back," said the boy, eagerly starting off.

The watchers waited impatiently; time seemed to them to pass slowly, but in reality in a short while the boy returned, leading a radiant stranger, the physician Hippocrates. He was between forty-five and fifty years of age — tall, erect, godlike in presence and calmness.

Three young men accompanied him, disciples learning the art. They were his sons Thessalus and Dracon, and one named Dexippus.

He entered the home of Philiscus gravely, greeted the wife and the two older men with a smile, and then walked quickly to the bed where the patient lay.

He put his hand on the sick man's forehead.

"Have you any pain?" he asked.

The patient stared at him vacantly, his lips trembling in a muttering delirium, and then he suddenly started as if to rise from his bed.

The younger physicians restrained him.

"Has he been delirious long?" Hippocrates asked the wife.

"Since yesterday evening," she answered.

"How long has he been sick?"

"This is the third day. He went to the market-place to discuss some

matter and stood in the sun, and something he said must have incurred the anger of the god."

Hippocrates lifted his hand to stop her.

"Tell the story just as it happened, without bringing in the gods," he said, somewhat severely.

The woman looked at him with some fear. Then seeing a reassuring smile from the physician, she continued:

"He came home and took to his bed. He sweated and was very uneasy. Yesterday, the second day, he was worse in all these points."

"Did he have a stool?" asked Hippocrates.

"Yes, late in the evening — a proper stool from a small clyster." [1]

"Write that down, Dexippus," commanded the master — and "Go on," he said to the wife.

"Today he has been much worse. He has been very hot. He trembles; he sweats and is always thirsty. He hath been delirious on all subjects. He passed black water."

"Oh! When was that?" asked the physician, suddenly alert.

"This afternoon."

"Let us see some of it."

A slave boy was summoned and brought an earthen vessel with some of the sick man's urine in it.

"Notice, my sons," said the physician to his disciples. "The black water again. We have seen it often this season. And always the prognostic is unfavourable."

"Anything more to tell us?" he asked, turning again to the wife.

"That is all, I think — O mighty physician, invoke the gods to drive this devil from my husband."

"Your husband hath no devil — he hath a disease. We will do our best. More we cannot promise. Pray to the gods, but pray for piety and good works. Do not ask them for things they cannot grant."

He left some instructions about the patient's diet and recommended lime-water to drink. He instructed the slave in bathing his master by sponging him with a cloth, unless he chilled. He left a draught of medicine to be given for delirium.

"I will return tomorrow and observe the patient," he announced to the family. "Let us see now, Dexippus, if you have that description right." He took the scroll from his pupil and read it.

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[1] *clyster*, enema.

"Shall we sacrifice to any of the gods?" asked the elder, tremulously.

"I do not practise by the gods," answered Hippocrates. "I try to discover the nature of the disease and to follow that. To read nature — believe me, friend, it is better than relying on the gods."

When he came the next day, the patient was unimproved. The physician noted all points about his condition and ordered Dexippus to write them down — which he did.

On the fifth day, however, the patient was worse. There was something very peculiar about the breathing.

Hippocrates motioned for the members of Philiscus' family to leave the room. Then, "What think you of that breathing?" the physician asked his pupils.

"It is passing strange," answered Thessalus.

"How would you describe it?" demanded his father.

The young man watched the patient for a few minutes and then said:

"Sometimes it is very rapid and deep — then it becomes shallower."

"Then what?"

"Then it stops altogether for a moment, and then he begins again like a person recollecting himself."

"That is good," approved the master. "Write that down, Dexippus — a splendid description — 'like a person recollecting himself.' — Good. There is no better description I ever heard. See, there it is — 'like a person recollecting himself.' Have you ever seen it before?"

"Yes — the Thessalonian had something like it."

"Quite true. And what was the outcome of his case?"

"He died."

"So he did. Do you remember anyone else who had it?"

"Was not that woman we saw in the little house yonder breathing in this way?" inquired Dracon, diffidently.

"She was indeed. Do you not all remember? Exactly the same. And what was the outcome of her case?"

"She, too, died," answered Dracon.

"That is the rule," said Hippocrates. "I have never seen one recover. So it will be here. I am sorry, for the wife loves her husband, but the rules of nature are immutable. Feel the spleen, Thessalus."

"It is large and round," answered Thessalus, after placing his hands on the abdomen.

"Extremities altogether cold," dictated Hippocrates, for his notes. "The paroxysms on the even days. Sweats cold throughout. So — "

The physician gave the family such comfort as he could, but his prognosis was fulfilled and Philiscus died that night.

How different this scene which I have attempted to portray from the picture of the son of Htebh and the medicine-man priest!

The method of Hippocrates the Greek was to ignore all of the gods. Disease, he preached, was a part of the order of nature, and to conquer it, to understand it, one must study it as one does any other natural event. Many useful facts about treatment and diagnosis and the classification of disease were gathered together before Hippocrates. But with him the doctrine that disease is a natural event and follows natural laws comes out clear and strong.

That is why Hippocrates is called the Father of Medicine. Yet how long it took men to learn the simple thing he taught! How many hundreds of thousands of years elapsed between Htebh and Hippocrates is a matter for the conjecture of anthropologists. Certainly not less than fifty thousand. But from his time to ours his influence extends in a clear stream, never changing in the great essential doctrine that disease is a part of nature.

The case of Philiscus is a good subject of study in order to analyse the elements which Hippocrates contributed to human thought.

Here we see him in the midst of his regular daily life, expounding by precept and example those principles. I have tried to show how far ahead of his time he was — how the older men in the scene harked back to the superstitions and to the ways of the gods of their youth — to Babylonian liver prognostication, to the idea of Apollo as the dealer of death, to the influence of Pan, and to the hounds of Hekate.

How scornful the Hippocratic writings are about the last: "But terrors which happen during the night, and fevers, and delirium, and jumpings out of bed, and frightful apparitions and fleeing away — all these they hold to be the plots of Hekate"!

The case of "Philiscus who lived by the wall" is actual enough. It is the first of those many little case histories found in Hippocrates — that earliest collection of clinical cases recorded from the standpoint of science.

The case is described simply day by day. There is no embroidery — simply the symptoms as they appeared and the outcome of the case.

The name of the patient, the address (by the wall), the circumstances, are all set down. The picture of the sick man tossing through the hot Athenian night comes to us across two thousand years, stabbing us like a personal anxiety.

The peculiarity of breathing which Hippocrates noted — "as of a person recollecting himself" — is now known as Cheyne-Stokes respira-

Clay model of sheep's liver; used by Babylonian medicine men to make diagnosis by divination.

tion. It is a common symptom of approaching death and is due to exhaustion or lack of oxygenation of the respiratory centre.

Hippocrates as a historical figure, aside from his writings, is very vague. In this he corresponds to Homer in the epic literature of Greece. It is doubtful if there was any single personality known as Hippocrates. The Hippocratic writings are probably the work of many men, the crystallization of the thought of a school.

Tradition dates his birth at 460 B.C. Plato mentions him as if he were

a living man known to him. He is said to have travelled widely, teaching as he went. He died at Larissa, it was said, at the age of a hundred and ten.

It is difficult for anyone who reads the Hippocratic writings to escape the conviction that the best of them were the product of a single mind — their unity of thought, their clarity, their radiance, preclude any other idea.

The best are the "Aphorisms" — short, descriptive, clinical facts. The most famous, of course, is the first: "Life is short and art is long."

But "Persons who are naturally very fat are apt to die earlier than those who are slender" might have a place in a modern life-insurance actuary's summary of his studies.

"Consumption most commonly occurs between the ages of eighteen and thirty-five."

"From a spitting of blood there is a spitting of pus" shows that Hippocrates has watched people with tuberculosis of the lungs have as the initial symptom a hæmorrhage and then begin ordinary expectoration.

"Eunuchs do not take the gout nor become bald."

"If a dropsical patient be seized with hiccup, the case is hopeless."

"Anxiety, yawning, and rigour — wine drunk with equal proportions of water removes these complaints."

Into the domain of treatment also he tried to bring some order.

His diets, for instance, as Dr. Singer points out, were to be prescribed according to certain sensible rules. First the age of the patient was to be considered — "Old persons use less nutriment than young." Then the season — "In winter abundant nourishment is wholesome; in summer a more frugal diet." The physical state of the patient — "Lean persons should take little food, but this little should be fat; fat persons, on the other hand, should take much food, but it should be lean." Digestibility of the food — "White meat is more digestible than dark."

The typical Greek myth has always seemed to my mind that of Prometheus. He stole the fire of the gods from heaven and brought it down to earth for man's use. The Greeks constantly did that. The Mediterranean basin was hag-ridden and god-ridden until they appeared. They took the drama — a service to the god — and they wrenched it away from the god and subdued it to the services of man. They made it not a service in a temple, but a story to charm the mind;

they filled it with music and dancing and song for their fellow-men's entertainment. So with Hippocrates. He took, once and for ever, " the art " — the art of healing. He wrested it from the gods and made it man's.

With Hippocrates — with all the Greeks — we first find people of our own kind. We come out, as Osler says — " out of the murky night of the East, heavy with phantoms, into the bright daylight of the West." Here are men speaking our words, following our devotions, thinking our thoughts, pursuing objects which seem to us worth gaining and to us understandable.

CHAPTER IV

GALEN, THE PHYSICIAN OF ROME

The Emperor of All Rome lay sick. The city was hushed. There was real grief among the people, for he was not only the most powerful, but also the wisest of men. His rule had been good, and in spite of considerable national insecurity his reign prosperous. He was Marcus Aurelius, the Stoic.

In the palace his condition gave rise to great concern. His frame, though naturally strong, had been taxed by the hardships of his campaigns against the barbarians. He did not seem to be able to shake off his malady. A succession of physicians had tried their arts — Egyptians, Sicilians — to no avail.

The Emperor's attendants and friends discussed his case night and day.

"If only we could persuade him to allow Claudius Galen to treat him, I would feel more confident," said one.

"It is not the Emperor; it is Arnuphus, the Egyptian physician, who keeps Galen out," answered the Chamberlain of the Palace, adding with a contemptuous laugh: "Fear! That is what animates Arnuphus. Fear that Galen will cure the Emperor where he has failed."

"These jealous doctors!" exclaimed a third man. "I spoke of Galen to them yesterday, and they turned their backs and walked away from me."

"They have bled His Majesty and bathed him until he is so weak he can hardly speak."

"They tell of wonders this Galen has performed. Glaucon, the philosopher, told me of an instance. He met Galen in the street and asked him to visit a sick friend whom Glaucon was going to visit — a Sicilian physician, by the way. Glaucon declares that he deliberately

tried to test Galen's powers and to that end told him nothing about the man's ailment.

"Nor did Galen ask a single question up to the time when he entered the sick-room. But going immediately to the patient, he put his hands over the upper abdomen and said 'Your pain is here'; and so, astonishingly enough, it was."

Glances of wonder and admiration passed between the members of the little group.

"But he did not stop there," continued the narrator. "He said to the patient: 'You have considered this to be a pleurisy, whereas indeed it is a disease of the liver.' . . . The patient was too overcome to do aught but nod his head weakly in agreement. 'You also have a dry cough occasionally which brings up no phlegm.' And, by the gods, Glaucon declares that before the words were out of his mouth, the patient had coughed in just the manner described."

"Did the man recover?" asked one of the group.

"The treatment was changed, and the man, on Galen's regimen, got well in three days."

"I have heard the same story," agreed another; "and this Sicilian physician goes everywhere with Galen to try to learn his art."

"The crowd of pupils which follow him from house to house, patient to patient, is the largest in Rome. I hear that he makes them spend much time in the dissection of the bodies of pigs. In this way they learn the secrets of life."

"A very sensible plan — better than studying the books of dead Greeks."

"He hath done many marvellous cures. Do you remember the wife of Servius Paulus? She fell into a melancholy, and nothing could rouse her until Galen came to attend. He whispered something to her and she laughed — and was cured. Servius Paulus told me so himself."

Fortunately for the peace of mind of these men, the Emperor at that moment sent for his Chamberlain and announced that he was willing to receive Galen. A messenger was dispatched forthwith.

The messenger found Galen just emerging from the house of one of his patients. As was customary at the time, he was surrounded by a rabble of students — forty or more — who shouted question after question about the case they had just seen.

Claudius Galen was a tall, bearded man, of almost exactly the Em-

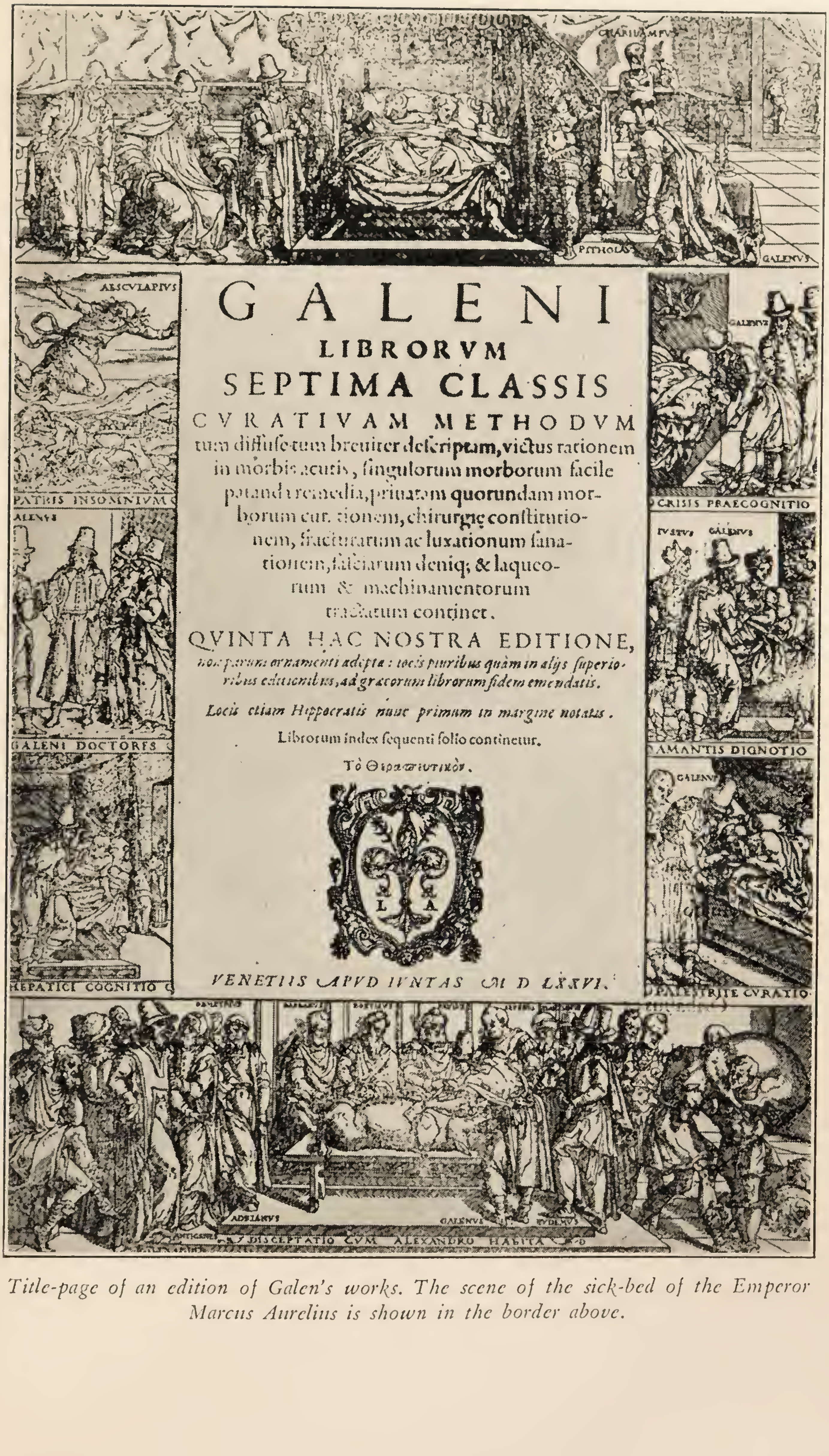
peror's age. He had a confident air and a rather vain look about his eyes and mouth. But this was softened by one's knowledge of his professional success.

On learning of the messenger's errand he dismissed his students and hurried with his conductor through the narrow streets.

Here adventurers of every sort jostled one another — mendicants, winesellers, slaves, courtesans, strolling actors, scribes, merchants, soothsayers, sailors, Roman soldiers, mercenaries, gamblers, and a few tired Stoic noblemen who walked with slow steps and disillusioned detachment.

The Emperor, propped up on his pillows, greeted his new physician with austere mien. He had lain for many days looking over the housetops of his city, of his empire, and his world. It was a different one from the Grecian world which this Galen represented. Its horizon was no longer bounded by the little islands of the Peloponnesus. It extended to the Himalayan Mountains on the east, around the basin of the Mediterranean to Africa and to Spain. Those clear-eyed, fair-skinned, lively people who walked the streets of Athens and of Melos had given place to a hard-minded, dark-skinned, Levantine race, who bustled up and down their narrow streets in straining, excited competition for commercial supremacy. Those beautiful little cities with the white temples on their green hills in that thin, clear, sunlit air against the sparkling waters of the pale Ægean Sea had been converted into great rattling hives of trade — the enormous brazen cities of Corinth and Antioch and Alexandria and Cæsarea and Rhodes, all of them existing under the ominous and dominating arm of Rome. Those childlike Grecian speculations — about the immortality of the soul and the nature of God — had been supplanted by a commercial philosophy, and all men's thoughts were turned to realities and the acquisition of gold.

The tired, sick Emperor was almost the only man in his empire who really cared for the old virtues of courage and the old ideals of beauty. And even as he lay there, he could hear the thud of one of his legions marching out to conquer some new part of Gaul and could see upon the distant hills the cloud of dust which marked the lurching troop of elephants, the rear guard of his regiments, as they trailed over the sun-baked plain upon the roads that led beyond the confines of the world.



GALENI
LIBRORVM
SEPTIMA CLASSIS
CVRATIVAM METHODVM
tum diffuse tum breuiter descriptam, victus rationem in morbis acutis, singulorum morborum facile parandi remedia, priuatam quorundam morborum curationem, chirurgiae constitutionem, fracturarum ac luxationum sanationem, fasciarum deniq; & laqueorum & machinamentorum tractatum continet.

QVINTA HAC NOSTRA EDITIONE, *non parum ornamenti adepta: locis pluribus quàm in alijs superioribus editionibus, ad graecorum librorum fidem emendatis.*

Locis etiam Hippocratis nunc primum in margine notatis.

Librorum index sequenti folio continetur.

Τὸ Θεραπευτικόν.

L A

VENETIIS APVD IVNTAS M D LXXVI.

Title-page of an edition of Galen's works. The scene of the sick-bed of the Emperor Marcus Aurelius is shown in the border above.

Thus physician stood before patient — the last of the Greeks before the last of the Romans.

"It is our opinion, and that of our physicians," said His Majesty, indicating the three doctors who, huddled in one corner, sullenly regarded the new-comer, "that there is a febrile paroxysm of some sort tormenting us. It makes me very weak."

In proof of this he was forced to lie back, exhausted, after the excitement of addressing his new attendant.

"It is the beginning of a paroxysm," said Arnuphus, and, with the others, he came forward and felt the Emperor's pulse.

They nodded gravely at each other. Galen stood aloof, a slight superior smile upon his lips.

"Why do you not also examine our pulse, Claudius Galen?" demanded the sick man.

"Two of these gentlemen have already done this, and probably when they were abroad with you, they already learned by experience the characteristics of your pulse; hence I expect they will be better able to judge its present condition (diathesis)."

"At any rate, I want your opinion. Do you also feel my pulse."

Galen stepped forward and portentously knitted his brows as he felt the pulse. At length he shook his head.

"I regret not to be able to agree," he announced finally, fixing his rivals with a direct and courageous stare. "Taking the age and constitution of His Majesty into account, the pulse is far from indicating the beginning of a febrile attack."

"What, then?" asked the Emperor sharply.

"Your stomach was overloaded with food, and prior to ejection it turned to phlegm," pronounced Galen.

Arnuphus glanced significantly at his fellow-consultants when this diagnosis was given out, and was about to interject an angry and sarcastic remark when the Emperor slapped his bed-clothes feebly, but with distinct approval.

"That's it," he asserted. "It is just what you say. I feel I have taken too much cold food."

Galen, who was all too human, raised his head in triumph and pursed his lips at his rivals. Had he not been in such an august presence, he would have stuck out his tongue at them.

"And now what is to be done for treatment?" continued Marcus

Aurelius, ignoring his former attendants and fixing his gaze devotedly on this new-comer.

And Galen, nothing loath, answered: "If it were anyone else who was in this state, I should follow my custom and give him wine sprinkled with pepper. But in the case of kings, like yourself, physicians are in the habit of giving safer remedies; hence it will be enough to apply over your stomach some wool impregnated with warm spikenard ointment."

"In any case," remarked the Emperor, "when my stomach is out of order, I am in the habit of applying warm spikenard ointment enveloped in purple wool over it. So your prescription suits me perfectly, my good Galen. I don't see why somebody didn't think of it before," he concluded petulantly, with a baleful glance at the discomfited Egyptians.

"Pitholaus! Send for Pitholaus!" continued His Majesty. "Where is the fellow? — he is never about when he is wanted."

"Here, Majesty, here," answered Pitholaus soothingly, stepping from behind the curtains.

"Did you hear what Dr. Galen said?"

"Yes, Majesty. I shall go at once and fetch the spikenard and wool."

Galen visited the palace the next day and was received with joy by Pitholaus.

"His Majesty is better — much better," reported the attendant. "I made the application as you directed, and it gave great relief. Then I treated his feet by rubbing with my warm hand. His Majesty felt so much better that he asked for some Sabine wine with pepper sprinkled in it."

Galen nodded. "Well done!" he exclaimed. "It would warm and dissolve the phlegm."

"It certainly improved His Majesty. He is on the way to recovery, I feel sure. And full of your praises, Master Galen!"

"What does he say?" inquired the physician.

"He says that he now has one physician and he is a perfect gentleman."

In less than a week the Emperor was well. He and his physician became fast friends. He delighted to send for Galen and have him explain his philosophy of disease.

"You must remember," the Pergamene would expound, "that there

are four humours in a man's body — blood, phlegm, black bile, and yellow bile. In health these are in perfect balance. That is what health is — to be in perfect good humour. But if one of these becomes out of balance and in the ascendant, you are out of health — you are in disease. You may have an ascendancy of black bile, in which case you are bilious. Or of yellow bile; then you are choleric or melancholy.

"Each man, too, has a certain temperament — a tendency for one of the humours to predominate. If it is the blood, we say he is a sanguine man. If it is the phlegm, we say he is a phlegmatic man. If it is the black bile, we say he is a bilious man. If it is the yellow bile, a melancholic man. And such a man is liable to be diseased in just such a way.

"As for treatment, you must know that each of these humours has a quality. Thus the quality of the blood is warm. When it predominates there is fever. The quality of phlegm is cold and moist. When it predominates, cold and moist diseases occur — such as chills or dropsy. So when one humour is in the ascendancy, we apply the opposite sort of a remedy — for dry, hot diseases a cold, wet remedy — a bath in cold water, liquid food, and so forth. Am I clear?"

"Perfectly," agreed the Emperor; "it is all entirely logical and sensible."

"All natural philosophy is logical and sensible," said the physician, sententiously.

"But tell me, now," continued the Emperor, with an eager light of curiosity in his eye, "how did you divine the disease that Glaucon's friend, the Sicilian physician, was suffering from?"

Galen laughed and looked shrewdly at his powerful patron.

"I fear, sire, that if I disclose my little secrets, you will no longer consider me skilful."

"Nay, my friend, that can never be. Besides, we princes should know all things that are to the benefit of our people."

"So —" replied the physician. "It is an amusing tale and I will tell it you. Remember, though, as I do so, that we poor mendicant healers must use our wits.

". . . Upon the occasion of my first visit to Rome I completely won the admiration of the philosopher Glaucon by the diagnosis which I made in the case of one of his friends. Meeting me one day in the street, he shook hands with me and said:

"'I have just come from the house of a sick man, and I wish that

you would visit him with me. He is a Sicilian physician, the same person with whom I was walking when you met me the other day.'

"'What is the matter with him?' I asked.

"Then, coming near to me, he said, in the frankest manner possible:

"'Georgias and Apelas told me yesterday that you had made some diagnoses and prognoses which looked to them more like acts of divination than products of the medical art pure and simple. I should like,

Roman physician (Dioscorides) and a lady patient. He is showing her the magic herb: the mandrake.

therefore, very much to see proof, not of your knowledge, but of this extraordinary art which you are said to possess.'

"At this very moment we reached the entrance of the patient's house, and so, to my regret, I was prevented from having any further conversation with Glaucon on the subject and from explaining to him how the element of good luck often renders it possible for a physician to give, as it were offhand, diagnoses and prognoses of this exceptional character.

"Just as we were approaching the first door, after entering the house, we met a servant who had in his hand a basin which he had brought from the sick-room and which he was on his way to empty upon the dung-heap. As we passed him, I appeared not to pay any attention to the contents of the basin, but at a mere glance I perceived that they consisted of a thin sanio-sanguinolent fluid in which floated excrementitious masses that resembled shreds of flesh — an unmistakable evidence of disease of the liver.

"Glaucon and I, not a word having been spoken by either of us, passed on into the patient's room. When I put out my hand to feel of the latter's pulse, he called my attention to the fact that he had just had a stool, and that, owing to the circumstance of his having got out of bed, his pulse might be accelerated. It was, in fact, somewhat more rapid than it should be, but I attributed this to the existence of inflammation.

"Then observing upon the window-sill a vessel containing a mixture of hyssop and honey and water, I made up my mind that the patient, who was himself a physician, believed the malady from which he was suffering was a pleurisy; the pain which he experienced on the right side in the region of the false ribs (and which is also associated with inflammation of the liver) confirming him in his belief and thus inducing him to order for the relief of the slight accompanying cough the mixture to which I have just called attention.

"It was then that the idea came into my mind that as fortune had thrown the opportunity in my way, I would avail myself of it to enhance my reputation in Glaucon's estimation. Accordingly, placing my hand on the patient's right side over the false rib, I remarked: 'This is the spot where the disease is located.'

"He, supposing that I must have gained this knowledge by simply feeling his pulse, replied, with a look which plainly expressed admiration mingled with astonishment, that I was entirely right.

"'And,' I added, simply to increase his astonishment, 'you will doubtless admit that at long intervals you feel impelled to indulge in a shallow, dry cough, unaccompanied by any expectoration.'

"As luck would have it, he coughed, in just this manner, almost before I had got the words out of my mouth. At this, Glaucon, who had hitherto not spoken a word, broke out in a volley of praises.

"'Do not imagine,' I replied, 'that what you have observed represents the utmost of which medical art is capable in the matter of fath-

oming the mysteries of disease in a living person. There still remain one or two other symptoms to which I will direct your attention.'

"Turning then to the patient, I remarked: 'When you draw a longer breath, you feel a more marked pain, do you not, in the region which I indicated; and with this pain there is associated a sense of weight in the hypochondrium?'

"At these words, the patient expressed his astonishment and admiration in the strongest possible terms. I wanted to go a step further and announce to my audience still another symptom which is sometimes observed in the more serious maladies of the liver — scirrhus, for example — but I was afraid I might compromise the laudation which had been bestowed upon me. It then occurred to me that I might safely make the announcement if I put it somewhat in the form of a prognosis. So I remarked to the patient: 'You will probably soon experience, if you have not already done so, a sensation of something pulling upon the right clavicle.'[1]

"He admitted that he had already noticed this symptom. 'Then I will give you just one more evidence of this power of divination which you believe that I possess. You yourself, before I arrived on the scene, had made up your mind that your ailment was an attack of pleurisy,' etc.

"Glaucon's confidence in me and in the medical art after this episode was unbounded."

The Emperor expressed himself as delighted at this anecdote.

"And now tell me," he requested, "how you cured the wife of Servius Paulus."

Galen smiled a wise and enigmatic smile.

"There, sire," he cautioned, "you entreat me to abuse a confidence. Still, as you say, an Emperor must know about his people, so I will relate it to you.

"When I was called to see her, any child could have recognized that her trouble was mental. A fool of a Bithynian physician was treating her as if she had an affection of the bowels. But I stopped all that and fell into conversation with her. I had heard her name as associated with that of an actor, Pylades, a handsome but brainless creature, a

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[1] Galen, from whose actual writings this extract is taken, is here describing the radiation of pain in gall-stones, which goes from the upper abdomen into the shoulder — a fact constantly used for diagnostic purposes today.

good dancer, but vain as the birds of Juno, so as we conversed — and I was feeling her pulse at the same time — I brought the conversation round to the theatre and mentioned my feigned admiration of Pylades' dancing. Her pulse bounded like a wave of the sea at the mention of his name and then increased its beatings, also skipping about like an eel. Thus I was reasonably certain of my diagnosis. But to make perfectly certain I went the next day and again engaged her in conversation. I brought up the name of another actor, Morphus, and her pulse remained as steady as the sun. But when I said that Pylades was dancing again, the pulse went skipping and running. So I laughed and whispered something to her, at which she blushed and agreed, and she began to mend."

"What were the words you whispered?" smiled the Emperor.

"That, sire," replied his friend, "would be improper for me to tell even my Emperor. But come," he suggested, rising, "let us continue our studies in a more practical way. My students are today dissecting a pig. Let us join them and I will point out certain things of value to you."

PART II

THE FUNDAMENTAL SCIENCES

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The influence of Galen lasted for fifteen hundred years.

All through the Middle Ages his system, which was essentially empiricism, was expounded by pedants, who taught the art of medicine by intoning the works of Galen to the rhythmic beating of the rod.

The Hippocratic canon was little studied or observed. Hippocrates was too austere, too liberated, too skeptical for that period of dogmatism. His discourse on the sacred disease, in which he scouts any divine intervention into human tribulations, was not at all in the mood of the Middle Ages.

But along with the Roman (or Greco-Roman), the Middle Ages were influenced by another stream of culture — the Arabian.

After Alexander, Greek culture spread and penetrated far into the lands of the Mediterranean basin. These lands included all those which were afterwards conquered for the prophet, Mohammed. Scholarship was enthusiastically encouraged by the leaders of the Mohammedan faith. It founded itself on Greek models. It was exact of its kind, and its kind — empiricism, like Galen's — suited the mediæval spirit.

The *Canon* of Avicenna is indeed, from the standpoint of the influence which it exerted, one of the greatest books of the world. That influence was by no means second to Galen's — rather, equal. Nor was it undeserved. "Avicenna is an intellectual phenomenon," says Leclerc. "Never perhaps has an example been seen of so precocious, quick, and wide an intellect extending and exerting itself with so strange and indefatigable an industry." And William Osler adds: "The touch of the man never reached me until I read some of his mystical and philosophical writings. . . . It is Plato over again."

About the time of the discovery of America, however, men became

newly inquisitive. The old theories ceased to satisfy them. This was as true of the structure of the human body as it was of the flatness of the earth.

Such a dawn figure as that of Paracelsus reminds us of Faust, with his passion for all-encompassing power and knowledge. He began to utilize the tricks of the alchemists for his own aggrandizement and founded chemistry in the process.

Galen's hold began to weaken. "God did not exhaust all His creative power in making Galen," exclaimed Henri de Mondeville, who taught surgery at the University of Montpellier, in 1304.

The great universities were founded. The printing-press made books comparatively cheap and universal. Men began to think for themselves. A transcendently alert mind, Leonardo da Vinci's, inquired into human anatomy to enrich his art and then continued out of curiosity.

And then suddenly, as it seems to us, looking back, men burst all the bounds of tradition and authority and superstition.

They began to build a knowledge of the human body in health and disease on fundamental science. They cast the old pedantry aside, started all over, and learned the structure of the human body from dissection of human (not animal) bodies. With this knowledge of anatomy they were able to study the functions of the body by experiment — intelligently planned — on human and animal bodies.

The two sciences of anatomy and physiology became the foundation of modern medicine.

CHAPTER V

ANATOMY — VESALIUS — THE STRUCTURE OF THE HUMAN BODY

A young man sits blindfolded in the council-room of the University of Padua. The year is 1537. The University of Padua, one of the first in Europe to give instruction in medicine, is already venerable — over three hundred years old.

The city of Padua lies in the flat, marshy country whose rivers join the Po and carry the silt down to form the islands on which the city of Venice stands beside the shores of the Adriatic. Since 1405 it has been under Venetian rule, and the winged Lion of St. Mark, the symbol of the Republic of Venice, is sculptured over the doorway of the university. We shall have much to do with Padua and the University of the winged lion in the next parts of our story.

Before the young man who sits blindfolded stand a number of doctors in long robes. They hand him one after another the bones from a disarticulated human skeleton which lie on a table beside them.

The young man holds each bone in his hands and feels it all over. The learned doctors are sure he cannot see through his blindfold.

"This is a scaphoid bone from the ankle," he announces.

A murmur of admiration from the audience attests the correctness of his pronouncement.

Another bone is handed him. He laughs derisively at the ease of his task this time.

"This is a shoulder-blade," he says.

And another. This one is not so simple. He feels it very carefully.

"This is a radius — one of the bones of the forearm," he says finally, and the audience of curious young dandies who have come to see a spectacle breaks into applause.

The robed professors nod approvingly. They go into conference and vote to make Andreas Vesalius the Professor of Anatomy in the University of Padua. There has never been a chair of anatomy in that ancient university before. The department is created for the young Belgian.

He enters upon his duties immediately. He frequently holds public dissections in the anatomical theatre. Students come to watch them, as well as the curious of all sorts — nobles and great men morbidly attracted by this spectacle of seeing the actual insides of a human body.

The days when Vesalius is to hold his dissections become famous. At the university doors, crowds gather, too large to be admitted. Spectators press about the dissection table, and hang upon the balustrades, climbing pillars, craning to see the parts he so deftly exhibits and so interestingly describes.

Neither the disapproval of the Church nor the instinctive horror of society towards the mutilation of the fleshy tabernacle of the soul restrains the professor or his audiences. Bodies are furnished him by the activities of enthusiastic admirers. They are obtained by rifling graves or robbing scaffolds. Indeed, the support of the rich and great to the project has become so manifest that the Church begins to condone the act of examining the human body after death and to modify its theological objections. Many monks and priests are to be seen in the audience at the demonstrations. For a time one of the most fashionable pastimes in Venice and Padua is to attend the anatomical lectures of Vesalius.

Andreas Vesalius, although only twenty-two or twenty-three years old, had travelled a long path before he demonstrated his proficiency to the faculty of Padua.

He was born in 1514 in Brussels. From the first, he was marked out as the possessor of uncanny powers — he was born with a caul, which his mother, good soul, proudly preserved throughout her life.

He came of a medical family, and the place of his birth was accidental, his father being apothecary to Margaret of Brabant, and the court happening to be domiciled at Brussels in the winter of 1514.

It was natural that early in life he should become interested in medical matters — especially dissections. When a boy, he repeatedly dissected small animals. He learned to swim by the aid of bladders and noticed the elasticity of these organs and speculated about their structure.

He was sent to the University of Louvain to study medicine, that Uni-

versity whose lovely buildings and priceless manuscripts were destroyed in the cataclysm of 1914.

The great centre of medical education in those days was Paris. The far-renowned Professor Sylvius taught anatomy there.

Professor Sylvius taught anatomy out of Galen — that same Galen whom we saw attending the sick-bed of the Emperor. His anatomy was based on the dissection of dogs and pigs, not human bodies. For nearly fifteen hundred years men had been teaching anatomy out of Galen.

Professor Sylvius sat above his class and read the book of Galen's called *The Use of Parts*. Suddenly he stopped and said: "Gentlemen, we now come to a part too difficult for beginners. Were I to go through it, we should only be bewildering each other."

Such things did not please Vesalius.

"Name of a name of a pig dog," he would exclaim to his fellow-students. "How are we to be anything else but beginners if he does not explain things to us? Why not explain out of something else than Galen, if Galen is too difficult?" And then, with a laugh:

"Let me tell you — I believe the professor himself does not understand."

Such blasphemies shocked his less original mates. From time immemorial medicine had been taught by pounding out the works of Galen and Avicenna. Vesalius' own great-grandfather had written a treatise on the works of Avicenna.

A dog was the usual object to be dissected before the class. As the dissection progressed, the professor would read what Galen said on the subject. Sometimes Professor Sylvius would find something in the course of dissection of the dog which did not agree with Galen. If so, he gave his class to understand the dog was wrong. Sometimes he was unable to find a muscle or tendon or nerve or vein which he had meant to show.

On one occasion he became so confused that he called upon Vesalius, whose reputation for skill in dissection was already known, to bring to light the missing part. Vesalius stepped to the dissection table and with a few movements of the knife and forceps exposed the part the professor had been unable to lay bare. Vesalius infected his mates with enthusiasm for the direct study of nature. Often when Professor Sylvius had encountered difficulties in exhibiting some part of the animal mentioned in Galen, Vesalius and his fellow-students would slip down after the

lecture and dissect the dog carefully for the missing part, until it was neatly exposed. On the occasion of the next lecture they tauntingly called the professor's attention to it.

"But dogs!" Vesalius would cry to his companions. "Dogs and pigs, they are not men. Why cannot we have a human body to dissect?"

This was doctrine more dangerous than the young radical's contempt for Galen. Neither the Church nor public opinion looked with favour on the dismemberment of the body after death. "The resurrection of the body" was a real thing. If you removed parts of the body, how would the owner function in heaven? What would one do without a spleen in the celestial streets?

"For purposes of ambition," says Henry Morley, in his essay on Vesalius, "living men might be blown asunder at the cannon's mouth, cut up with sword and ax, or probed into with military lances. For the purposes of science dead men were not to receive a wound." That this was actually the Church's attitude there is, in spite of the protests of certain apologists, ample proof. Mondino, Vesalius' most notable predecessor in anatomy, exhibited for dissection three bodies in the years 1315–18 and thereby caused a great scandal. The bull of Boniface VIII was threatened against him. Mondino would not clean bones and thus be able to study them carefully, because of the sin involved. This sin was defiance of the aforesaid bull of Pope Boniface VIII, which provided for excommunication of those who boiled bones. The edict was not directed at anatomists, but at the custom of boiling bones of such persons as crusaders in order that the bones, their remains, might be brought back to their own homes. The anatomical text of Guido de Vigevano, published in 1345, while it shows dissections, notes that the Church prohibits them.

But Vesalius was made of the true stuff of skeptics, if not of martyrs. "Never," he wrote, "would I have been able to accomplish my purpose in Paris if I had not taken the work into my own hands."

He dissected dogs and pigs and boldly made corrections in Galen's descriptions. But this did not satisfy him. He wanted human bones and human bodies.

Perhaps he remembered a passage in Galen. "First of all, then," wrote Galen, "I would ask you to make yourself well acquainted with the human bones, and not to look on this as a matter of secondary importance. Nor must you merely read the subject up in one of these books

which are called by some 'The Skeleton.' Examine the bones themselves in your own hands.

"Personally, I have very often had a chance to do this where tombs or monuments have become broken up. *On one occasion a river, having risen to the level of a grave, easily disintegrated it; then by the force of its current it swept over the dead man's body, of which the flesh had already putrefied, while the bones were still closely attached to one another.* And here the latter lay ready for inspection, just as though prepared by a doctor for his pupil's lesson.

"Once also I examined the skeleton of a robber, lying on a mountain-side a short distance from the road. This man had been killed by some traveller whom he had attacked, but who had been too quick for him. None of the inhabitants of the district would bury him; but in their detestation of him they were delighted when his body was eaten by birds of prey; the latter, in fact, devoured the flesh in two days and left the skeleton ready, as it were, for anyone who cared to enjoy an anatomical demonstration."

"Could I get a skeleton?" Vesalius asked himself.

Montfaucon, the Paris hill so well known to readers of Villon, was the site where criminals were executed. By day and by night Vesalius prowled this spot, picking up a subject as occasion offered. Not only did he have to outwit the authorities, but on at least one occasion he was compelled with a fellow-student to fight a pack of dogs who had gathered to eat the flesh of the departed malefactors and who turned upon the two anatomical students and nearly rent them alive.

Such activities could not have made for popularity. Especially with Professor Sylvius, whose words Vesalius arrogantly derided; whose ability at dissection he cleverly surpassed. Perhaps these were the reasons for his leaving Paris. At any rate, about 1535 we find him returning to Louvain.

In Louvain he continued to haunt the neighbourhood of the scaffolds. On one occasion, accompanied by his friend Régnier Gemma, he came upon the remains of a noted robber. This one, "since he deserved more than ordinary hanging, had been chained to the top of a high stake and roasted alive. He had been roasted by a slow fire made of straw, kept burning at some distance below his feet. In that way there had been a dish cooked for the fowls of heaven, regarded by them as a special dainty. The sweet flesh of the delicately roasted thief they had preferred

to every other. His bones, therefore, had been elaborately picked, and there was left suspended on the stake a skeleton dissected out and cleaned by many beaks with rare precision. The dazzling skeleton, complete and clean, was lifted up on high before the eyes of the anatomist. That was a flower to be plucked from its tall stem.

"Mounting upon the shoulders of his friend, and aided by him from below, young Andreas ascended the charred stake and tore away whatever bones he found accessible. With stolen bones under their clothes, the two young men returned into Louvain.

"But in the evening Vesalius went out alone to take another walk, and suffered the town gates to close against him. He had resolved to spend the night afield under the stars; while honest men were sleeping in their beds, he meant to share the vigil of the thieves. There were the remains of the skeleton. At midnight none would dare to brave the spectacle of fleshly horrors among corpses of the wicked, under rain, moon, stars, or flitting night-clouds. Certain, therefore, that no man would come to witness his offence, Vesalius at midnight again climbed the tree to gather its remaining blossom. By main force he deliberately wrested the whole set of bones out of the grasp of the great iron fetters, and then having removed his treasure to a secret spot, he buried it. In the morning he returned home empty-handed. At leisure then, and carefully, he smuggled through the gates, day after day, bone after bone. But when the perfect skeleton was set up in his own house, he did not scruple to display it openly and to demonstrate from it, giving out that it had been brought by him to Louvain from Paris."

In this period he made the first public dissection which had been witnessed in Louvain for eighteen years.

During this time he made many drawings of parts of the body — of all the bones, of the heart, and lungs, and liver, and kidneys, and brain, and blood-vessels, and nerves. Made them from life, with the specimen actually before him.

What mistakes he found in the older authors! That rib which Adam lost, and which all male bodies were supposed still to be without. Nothing of that kind in the bodies he dissected!

That two-horned womb! Or seven-horned womb! Of course, the lower animals, with their multiple litters, had multiple-horned wombs. And, of course, Galen, who dissected animals, transferred a two-horned

womb to human females. But it wasn't there! A simple, single-chambered uterus was all Vesalius ever found.

The sternum or breastbone! Galen described it as having seven parts. But Vesalius could find only three bones to make it up — the manubrium, or handle; the gladiolus, or blade; and the xiphoid, or tip.

What a field for an honest man with open eyes, unfettered by old teachings! The whole human body was for him to describe. So he made drawings and notes until his manuscript grew to enormous proportions.

He must have been happy and excited in those great days of discovery and creation. But the shadows begin to fall around him at Louvain.

Here he is, dissecting busily, whistling at his work, pausing for a moment, tongue between lips, to get just the right shading on the sketch of that bone, when there is an almost silent slinking of soft feet behind him.

"Ah, Master Andreas, anatomizing a body again!" purrs a silky voice, and Vesalius turns to look into the sneering face and narrow eyes of a dark-robed priest.

"Yes, yes!" he answers eagerly. "See here. Let me show you, Brother Athanasius!"

"Ah!" murmurs the priest; "and where is the seat of the soul, Master Andreas? Show me that!"

Vesalius throws his head back and guffaws his great breezy laugh. "That I cannot do, Brother, because in all my dissectings I have never found the seat of the soul."

"Mm," answers the priest, and his smile is gone now. There is a glitter in his eyes. "Let me give you a piece of advice, Master Andreas — do not let your indulgences lead you into any indiscretionary dissipations!" And he is gone.

Vesalius could have cut his tongue out for that intemperate remark. He is as brave as any man, moral courage he has as much as any, but these priests, they are very ready to light fires now, and burning is not a pleasant death.

Besides, he is not ready to die yet — his work is unfinished. He must write his book. He must put his notes in order. He must find an artist, with more skill than himself, to make these sketches seemly.

And he must hurry if he is to have the honour of being the first. The idea of a new anatomy is all about in the last few years since so many dissections have been permitted, or done, permission or no permission.

"There was that fellow who was prosector with me in old Andernach's class in Paris," he muses. "What was his name? The Spaniard — Servetus — Miguel Servetus. True, he was more of a theologian than an anatomist. And a damned queer theologian. Here I only deny the infallibility of Galen, but he denied the godhead of Christ. Very much interested in the body though, because it had the vital spirit. And some keen iconoclastic notions about it, too. And a writer. He might write such a book as mine any day — any minute!"

Where to go? In any event, he must leave Louvain, and so he does, carrying his precious sketches and notes with him. He spends a time in the Army of the Emperor Charles V to obtain funds and protection. He can fairly hear the crackling of the faggots which the sneering searcher for the soul's seat would like to light under him.

South! South is the way for him! In Italy there is freedom. The great universities of Padua and Bologna are trying to liberate men's minds. He works his way down. He stops at Basel. His friend John Oporinus is Professor of Greek there, and also he has a printing-press. Vesalius shows him the notes and drawings. Oporinus agrees to make them into a book.

He gives Vesalius letters — to the faculty at Padua and to an artist, a pupil of Titian, Jan van Kalkar, whom he thinks would make the drawings for him.

And so he wins his chair at Padua, as we have seen. And he and Jan Stephanus van Kalkar set to work on the great book.

"Hurry! Hurry!" is his constant cry. "I must drive on. Someone may precede me."

More disquieting news comes to him. A fellow called Dryander, in Marburg, has published an anatomy. And obviously stolen some of Vesalius' figures! Where he got them, Heaven only knows, but probably while Vesalius was expansively showing them around. That foolish pride!

And this free Italy is perhaps a shade too free. Artists! It is overrun with artists. And they all want to dissect and draw the human body so that their representations of it will be more accurate.

There is a fellow named Canano, who lives in Ferrara, not far from Padua, who has come over to show him some marvellous drawings of muscles. And one Berengerio! He hears vaguely of this book with good pictures of skeletons and muscles.

Andreas Vesalius (1514–64). He gave the world the first accurate human anatomy. 1543.

But finally his own book is finished.

De Humani corporis fabrica, he calls it — *On the Fabric* (*Structure*) *of the Human Body.*

The drawings and the text are sent off to John Oporinus with a letter. Vesalius hopes they will not be damaged in transit. And safely enough, in 1543, the book appears.

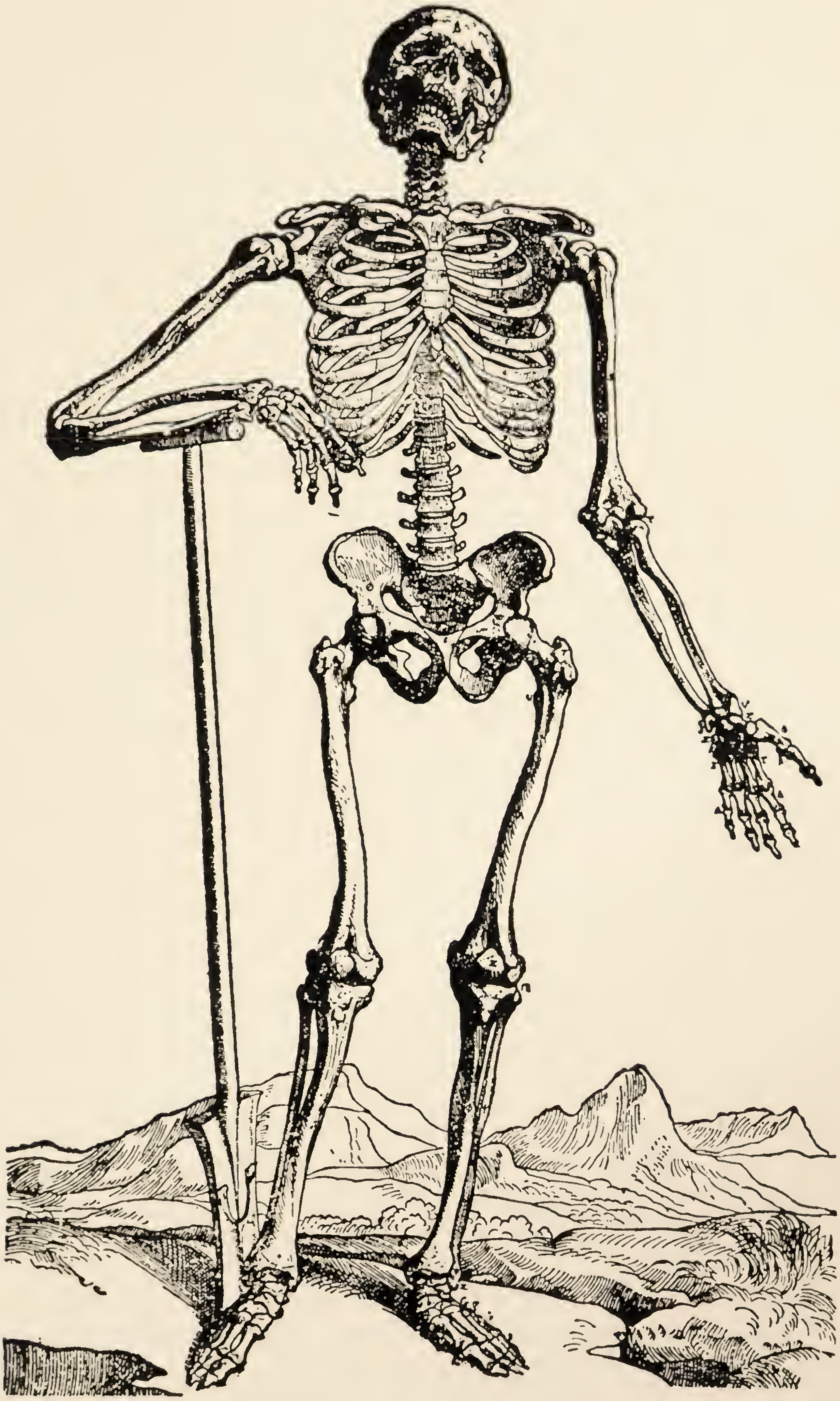
Two forms of the material were published in that year — the full text and an epitome.

In exactly the same year there appeared Copernicus' great work *De Revolutionibus orbium cœlestium* (*On the Revolution of the Celestial Bodies*). It disproved the old theological doctrine that the earth is the centre of the universe. Just as Vesalius showed that man's structure is of the same material as the bodies of the lower animals. No mystical substance especially animated by the breath of God! The two books may well be regarded as peers in their power to free men's minds from the binding thongs of dogma.

It is impossible in a short space, and unnecessary, to detail all the discoveries Vesalius made in anatomy. I have already indicated some of them. He made a clean sweep. He put all anatomy on a new basis — discarding the many errors of the past, and founding the whole science on direct observation.

True, he made some mistakes. Not for seventy-five years was the exact nature of the circulatory system to be understood. And he left some omissions. There were a few things for his great successors to discover.

There are those who think in such a way that they believe the credit of being the first great anatomist should go to Leonardo da Vinci. That great humanist did indeed turn, in his later years, from art to science and he did work systematically at human anatomy. And many years before Vesalius. Familiar he must have been with Galen, and, just as Vesalius did afterwards, he rejected him and went to the book of nature itself. His drawings of the body — 750 in number — are the wonder and delight of all modern anatomists. But they were never published in his own lifetime. In fact, they were never published in their entirety until less than twenty years ago. They had no influence on thought. They directed no expedition against ignorance or superstition. As a modern anatomist says, "Leonardo was the first to create a new anatomy, but he created it for himself alone: Vesalius demonstrated a new anatomy to the world."



The skeleton as shown in Vesalius. 1543. It has been supposed that this was one of the figures which suggested the stage directions for the grave-diggers' scene in Hamlet.

The final judgment on the book of Vesalius will probably be that pronounced by Osler: "The greatest book ever printed, from which modern medicine dates."

The reception of Vesalius' anatomy by his contemporaries was, on the whole, enthusiastic. There were some dissenting voices. That old Sylvius in Paris would not be weaned from his Galen. When he heard that Vesalius described structures differently from Galen, he only remarked that "man had changed since Galen's time and not for the better."

The remainder of his life after the publication of his book (in various editions) is simply told. There were some changes of residence, to Bologna and Pisa; then Vesalius suddenly left Italy and became court physician to the Emperor Charles V. The reasons for this change are unknown. The air of controversy and opposition at Padua and Bologna may have disgusted him. In a fit of depression he destroyed many manuscripts. Perhaps no reason other than the appointment need be offered. Charles V was then the Emperor of most of the world—Spain, the Low Countries, Germany, the new land of America, much of Italy. To be physician to such a one was a badge of honour.

For twenty years, at any rate, he served in this capacity. He went to the wars, he rescued his patron from a mortal disease, he predicted the death day of Maximilian d'Egmont. Then in 1564 he left Madrid and the court. No certain facts explain this move. A contemporary letter states that "Vesalius, believing a young Spanish nobleman whom he had attended to be dead, obtained leave of the parents to open the body for the sake of inquiring into the cause of the illness, which he had not rightly comprehended. This was granted; but he had no sooner made an incision into the body than he perceived the symptoms of life and, opening the breast, saw the heart beat." This coming to the knowledge of the parents, Vesalius was reported to the Inquisition. He was saved from their punishment by the Emperor on condition that he undertake a penitential pilgrimage to the Holy Land. This duty was performed. In the meantime Fallopius, who had been Professor of Anatomy at Padua in the absence of Vesalius, died. Vesalius was appointed once more to the chair. On the way back to Italy, his ship was wrecked and Vesalius was washed ashore on the island of Zakynthos (or Zante), on October 15, 1564. His body was found there many months afterwards.

Anatomy developed very rapidly, so that within a hundred and fifty years there was little or nothing to add to our knowledge of it. The great names in anatomy are left like street signs on the various parts of the body, and ring in the conversations of every medical student.

Fallopius (1523–62) was a pupil of Vesalius and left his name on the Fallopian tubes, which convey the ovum from the ovary to the womb.

Eustachius (circa 1552), a contemporary, left his name on the Eustachian tube, which goes from the back of the throat to the ear. His great book on anatomy, with magnificent plates, was completed almost simultaneously with Vesalius' work, but had a curious history. The plates were presented to the Pope, who for some reason — possibly disapproval of the practice of dissection — put them away in the papal archives. There they remained for 162 years, until discovered by Pope Clement XI, who presented them to his physician, Lancisi. Lancisi published them belatedly in 1714.

Varolius (1543–75) left his name on the pons Varolii, in the brain.

Vidius (died 1569) left his name on the Vidian nerve.

De Graaf (1641–73) left his name on the Graafian follicles of the ovary.

Willis (1622–75) left his name on the circle of Willis (blood-vessels in the brain).

Glisson (1597–1677) left his name on Glisson's capsule of the liver.

Brunner (1653–1727) left his name on Brunner's glands, in the intestine.

Stensen (1638–86) left his name on Stensen's duct, which goes from the parotid (salivary) gland to the mouth.

Winslow (1669–1760) left his name on the foramen of Winslow in the peritoneum. Oliver Wendell Holmes used to open his lectures on the sphenoid bone, one of the most complicated and puzzling of human structures, by saying: "Gentlemen, damn the sphenoid bone." Most medical students feel the same way about the foramen of Winslow.

The list is long. Meckel's ganglion, the crypts of Lieberkühn, Scarpa's triangle, the foramen of Munro — all these catchwords represent the work of men who once lived and investigated and hated and hoped.

A professor of anatomy in our time in announcing a few minor discoveries said that the harvest of anatomical knowledge might be compared to that of a field of grain. The first harvesters found an untouched territory and they carried away great wagonloads of golden knowledge.

(In anatomy the harvesters were Vesalius, Eustachius, Fallopius, Columbus, Varolius.) Then came the gleaners, who went over the field and were rewarded by finding many sheaves left by their predecessors. (In anatomy the gleaners were de Graaf, and Winslow, and Bartholinus, and Stensen, and Wharton, and Glisson, and Willis, and Meibom.) They nearly cleaned the field. There are, of course, a few grains left. Now and then some geese enter and one picks up a little grain overlooked by the others, and the cackling he makes can be heard for miles. "Gentlemen," concluded the anatomist to his confreres, "we are the geese."

CHAPTER VI

THE BEGINNINGS OF PHYSIOLOGY—HARVEY AND SERVETUS

Some time during the last years of the sixteenth century (1599 in all probability), about the time Shakspere's plays were making such a furore in London, a swarthy, bellicose young Englishman named William Harvey entered into the ancient city of Padua and prepared to enroll himself as a student in the university.

He had graduated in 1597 from Caius College, Cambridge, and had decided to complete his medical education at the Italian University, made famous for its anatomy by Vesalius. Caius College (which is still pronounced "Keyes" College, its founder being Sir John Keyes, whose name Latinized is spelled "Caius") directed his bent strongly towards anatomy, as Sir John was the first to introduce the study of practical anatomy into England.

Young Harvey had wandered down to Italy over much the same route that Vesalius had travelled seventy years before. It was a leisurely journey through the Low Countries, down the Rhine, through Switzerland perhaps, and over the Alps.

Everywhere he went, Harvey heard of the fame of the Professor of Anatomy at Padua, Fabricius of Aquapendente. Fabricius had been a pupil of the great Fallopius, who had been, in turn, a pupil of Vesalius himself, so that the succession was authentic. Fabricius had built a magnificent anatomical theatre at Padua. It was arranged with seats in tiers around the little space in the centre where the body under dissection lay upon a table. This allowed everyone to obtain a seat with a good view of the subject. The theatre is still preserved exactly as it must have been in those days when William Harvey sat on the benches.

Harvey acquitted himself creditably at Padua. He was elected councillor of the English nation (that is, the English students), a post which involved the duty of getting drunk forty times a year. As one enters the courtyard of the medical school of the university today, where medical students are loitering in little groups, discussing the human body, which will ever remain their most fascinating topic, the first thing that strikes the American visitor is the blaze of colour from the stemmata, or coats of arms, of former students and professors placed upon the wall. Proper search will uncover the one belonging to "Gulielmus Harveus, Anglus" (William Harvey, the Englishman).

Early in his career as medical student at Padua, Harvey began to hear discussed the mooted question of the anatomy of the heart and blood-vessels. Vesalius had thrown so much doubt on the authority of Galen, that his ideas were no longer cherished, but still there was a sneaking adherence to them. And Vesalius was not so clear in the true anatomy of the heart and vessels himself.

The popular idea is that Harvey discovered the fact that the blood moves, propelled by the heart. But that is not an exact statement of his contribution. What he did was to prove that the blood moved *in a circle,* and he demonstrated the exact path over which it moved.

People have written that because Shakspere makes Brutus say to his wife (in the play of *Julius Cæsar*):

> "You are . . .
> As dear to me as are the ruddy drops
> That visit my sad heart,"

Shakspere might claim priority in being the discoverer of the circulation of the blood.

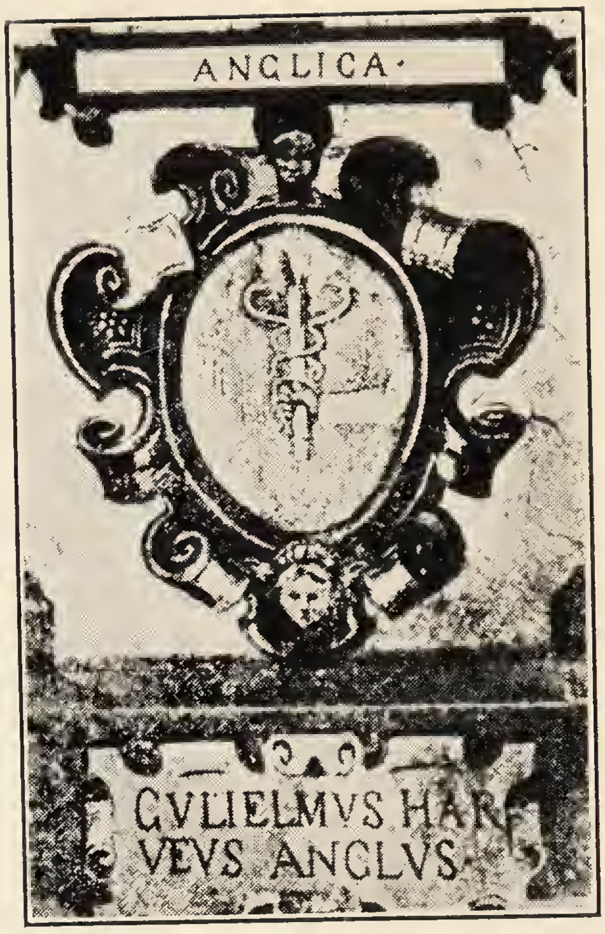
But this is not the circulation of the blood. This is only the motion of the blood. The ancients all recognized the motion of the blood. Galen had a very elaborate explanation of it. And we must examine that explanation which dominated medical thought for fifteen hundred years before we can understand Harvey. There is as much difference between the Galenical and Harveian circulation as between the Ptolemaic and the Copernican astronomy.

Unfortunately, the explanation of both involves rather technical discussion. I have tried to make it as plain as possible, but the reader will

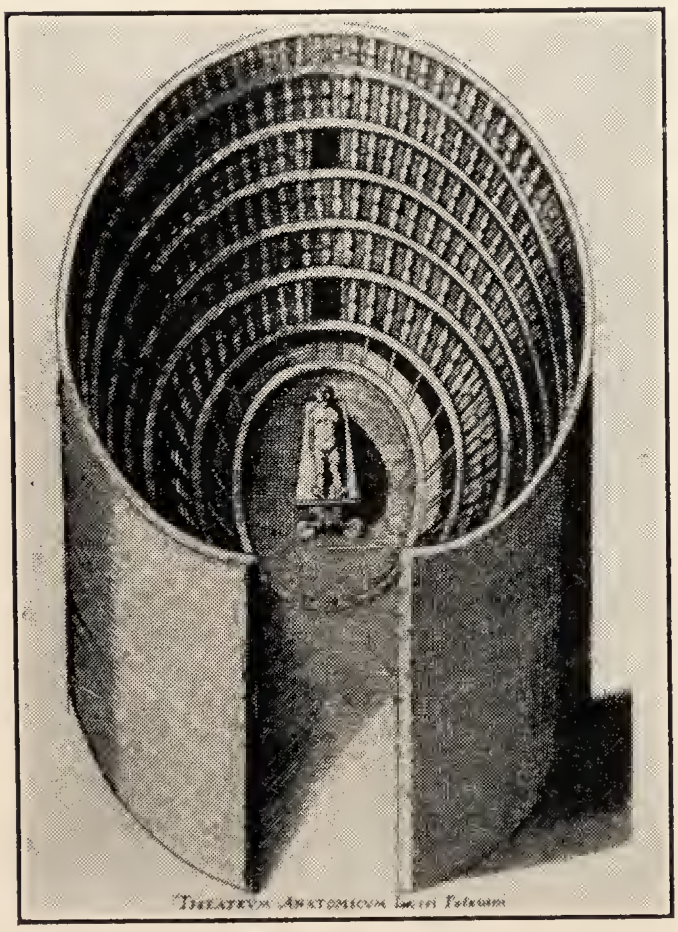
Entrance to the old anatomical theatre of the University of Padua. Print of 1623.

Photograph of the entrance to the anatomical theatre of the University of Padua as it is to-day. Note the winged Lion of Saint Mark, showing that Padua belonged to the Republic of Venice. Under this portal walked Vesalius, Fabricius, Harvey, and Morgagni.

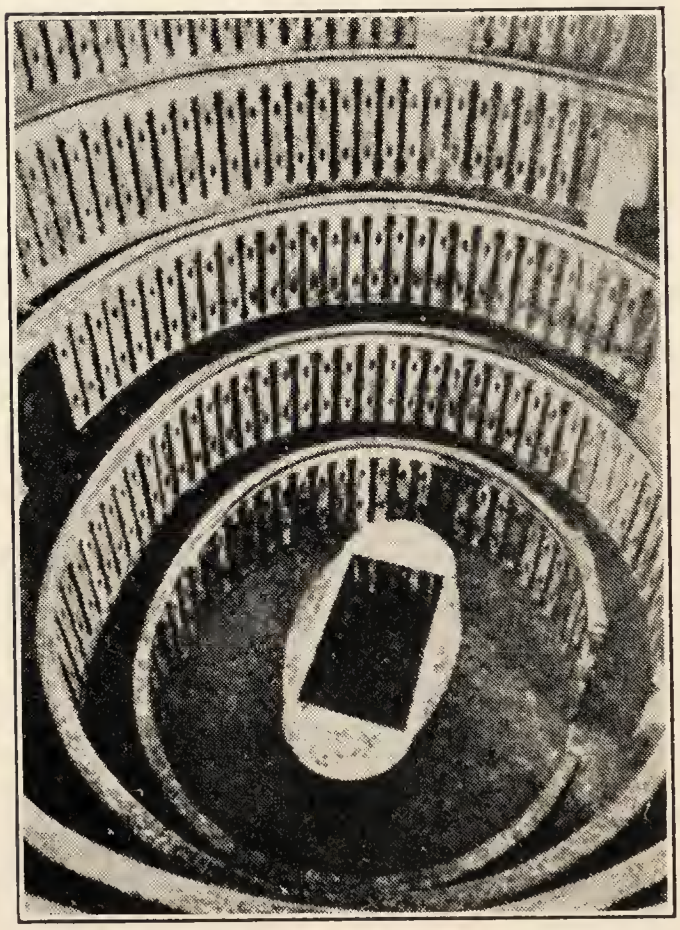
Fabricius of Aquapendente, the teacher of William Harvey.



Stemma of William Harvey, on the walls of the colonnade of the Medical School, Padua.



The old anatomical theatre at Padua. From a seventeenth-century print. Here all modern medicine began.



The anatomical theatre at Padua. From a recent photograph.

do no great violence to the continuity of my narrative if he skips the next few pages.

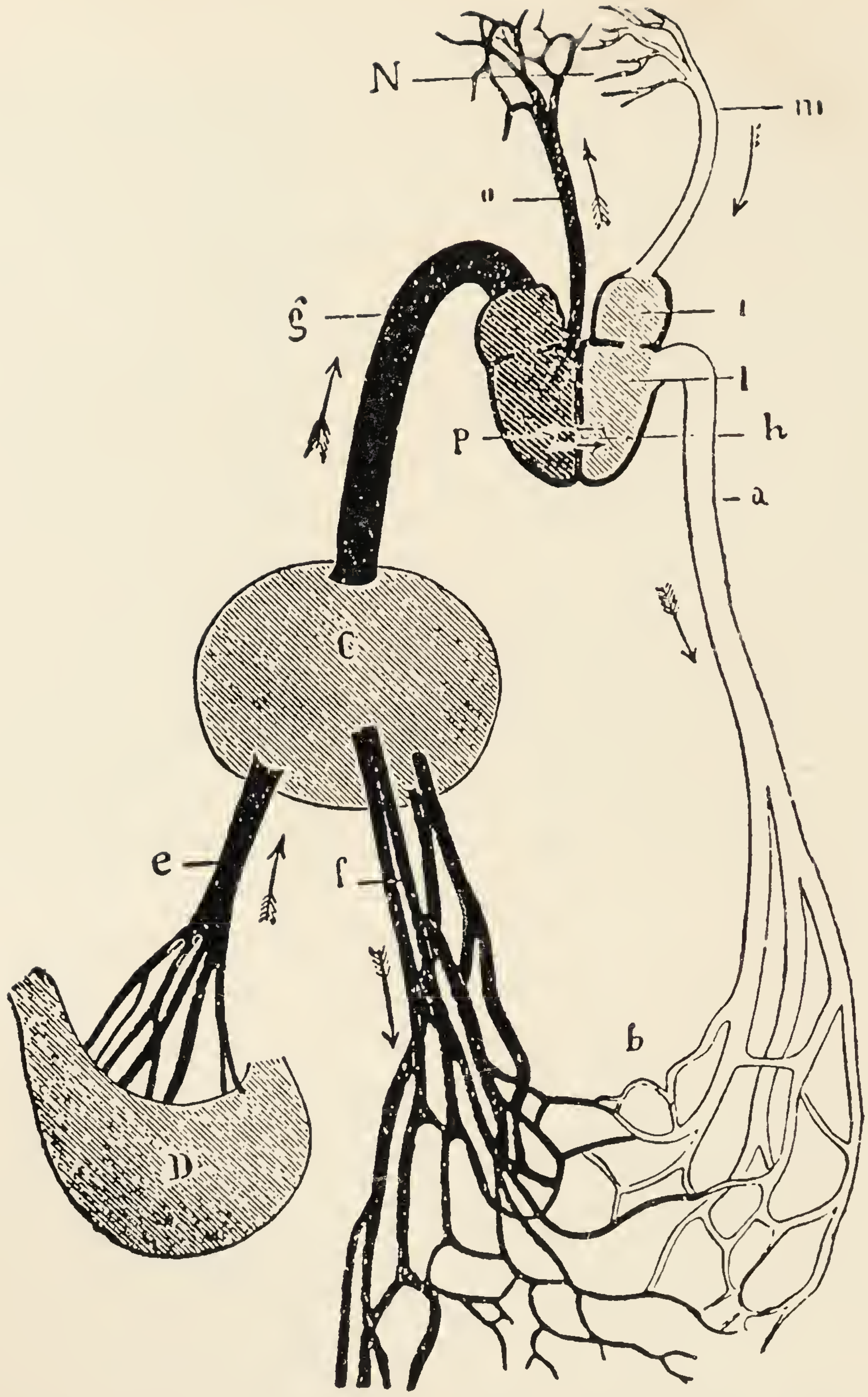
Galen based his ideas of the function of the heart and blood-vessels on the appearance of the organs after death. His anatomical observations were fairly sound, but his theories tripped him up. The first of these false theories was that both the heart and the liver were pulsating organs which drove blood through the body. The second was that three kinds of "spirits" were necessary for life — "vital spirits," distributed by the heart, "natural spirits," distributed by the liver, and "animal spirits," distributed by the brain.

Let us examine his anatomical facts first. The arteries after death are empty; the veins are full of blood. Galen knew that the large arteries come out of the left side of the heart. He knew that all animals need air; he saw that the arteries were full of air after death. So he declared that the left heart pumped air to the different parts of the body through the arteries.

Where did the air come from? A large blood-vessel coming from the lungs enters the heart. This also Galen knew from dissection. What more natural than to suppose that the air which the heart pumped should be brought from the lungs through this vessel?

What was the blood in the veins? One can see by the simplest dissection that some of the largest veins arise in the walls of the stomach and intestine and, coalescing, enter the liver from below — the portal veins. Also that large veins connected with the liver go to all parts of the body. Food is the basic nourishment of the body, Galen knew, and he said that the stomach and intestines change food into *natural spirits*. These natural spirits, Galen said, were absolutely essential to life. They were brought from the stomach and intestines to the liver and distributed through the veins to all parts of the body in a kind of ebb and flow by the gentle pulsations of the liver.

From the liver, too, a large vein went to the right heart, and from the right heart a vessel (which Galen called the "arterial vein," and which we call the "pulmonary artery") entered the lungs. What did this do? Galen knew that if people breathed in a close room for a time, the air became stale; therefore their exhalations contained impurities. Therefore, he theorized, this arterial vein brought the impurities manufactured in the body to the lungs, where they were cast off in the act of breathing.



Galen's theory of the motion of the blood. Galen's ideas, though entirely erroneous, were based on anatomical observations, and his anatomy is fairly sound, except in the establishment of connexions between the right and left ventricles of the heart. He conceives of two organs propelling blood into the tissues — the heart and the liver. The two systems — venous and arterial — are entirely separate. The arteries are represented as white and empty: air and blood are forced from the left heart into them, bringing the " vital spirits " to the tissues. The venous circulation centres in the liver (C); *it receives blood from the stomach and forces blood to the right heart, as indicated by the arrow* g; *it also forces blood into the extremities through the veins* (f). *This venous blood contains the " natural spirits " formed in the liver — i.e., digested food. The right heart forces blood to the lungs, through the " arterial vein "* (*arrow* o), *which in modern anatomy is called the " pulmonary artery." The purpose of this was to discharge the impurities gathered up by the venous blood in the air. Blood makes its way into the left ventricle from the right ventricle through channels* (*purely imaginary on Galen's part*) *in the septum between the two ventricles* (P). *The vessels entering the left heart from the lungs* (m), *called by Galen the " venal artery," in modern nomenclature " the pulmonary vein," he conceived as bringing air from the lungs to be distributed by the left heart to the tissues through the arteries.*

The vessels going to the brain, Galen believed, carried material which the brain changed into "animal spirits" and distributed to all parts of the body through the nerves.

There was one other point. Galen knew that if you cut an artery during life, blood came out, in a hissing stream. It was red in colour, contrasting with the purplish blood in the veins. Here was a difficult set of contradictions. Air and blood both in the arteries! And how did blood get to the left side of the heart? The venous blood carrying the natural spirits went to the right side of the heart.

Galen constructed an ingenious theory to account for these things. He affirmed that the most important thing the arteries carried was air. But he said the air would do no good unless accompanied by these potent natural spirits; so some blood with the contained natural spirits was mixed with it. As to how the blood got from the right to the left side of the heart, Galen declared it passed through small holes in the septum between the right and left ventricles. True, no one could see any holes. But there are a number of blind pits in the septum, and Galen believed these were openings into minute channels. Possibly, Galen also suggested, blood sweated through the septum, just as perspiration appears on the surface of the skin; if objection said that there are no holes in the septum, he answered that there are no holes in the skin.

Vesalius had profound doubts about these things, but he made little improvement in Galen's scheme. Even after the establishment of anatomy on a firm basis, the problem of the circulation was too tough a nut for the minds of the Renaissance to crack.

All but one. In our sketch of Vesalius we heard him recalling the name of a Spaniard who was his companion at dissecting in Sylvius' anatomy classes. His name was Michael Servetus. We must pause a moment to glance at his doctrine and his fate.

Just before noon on October 27, 1553 the town square of the ancient city of Geneva was crowded with an excited throng of its burghers.

The Spanish heretic was to be sentenced and burned. While a fugitive in Geneva, he had been recognized in church. He had thought to sneak out of Geneva and escape by boat across the lake, on his way to Zürich and Venice. But he was intercepted and arrested.

Then he had been tried, and the wicked fellow had impudently dared dispute theological doctrines with John Calvin himself. He had long ago rejected the doctrine of the Church of Rome, into which he had

been born, and now he had even rejected the doctrine of the new Protestant faith of the Reformation. There was no pleasing such a person. What was the world coming to? Could a man dare say all the churches were wrong? Well, he had the worst of that controversy with Calvin, and now his hour was at hand.

The tribunal before which he had been tried assembled on the porch of the Hôtel de Ville, as the little procession, with guards surrounding the prisoner, walked slowly across the sunlit square. Then for the last time the prisoner faced his judges, the dusky pallor of his long Spanish face contrasting with the blazing arrogance of his deep-set brooding eyes.

"The process against Michael Servetus of Villanova in the Kingdom of Aragon, in Spain," read the officer to whom that duty was delegated, "in which he is charged:

"First, with having between twenty-three and twenty-four years ago caused to be printed at Hagenau, in Germany, a book against the Holy Trinity, full of blasphemies."

Yes, yes! That was the book called *The Seven Books on Mistaken Conception of the Trinity,* thought the good townsmen, and hoped no young folk would hear or understand the dangerous words of the process.

"Item," the clerk droned on, "not only with having, in spite of this, persisted in his errors and infected many with them, but with having lately had another book clandestinely printed at Vienne in Dauphiny, filled with the like heresies and execrable blasphemies against the Holy Trinity, the Son of God, the baptism of Infants. . . ."

Oh, well, that book was out of danger anyhow. The *Christianismi restitutio — The Restitution of Christianity* — such was its name — all five hundred of the copies printed had been burned, along with an effigy of the author, at the place of public execution of Vienne just a few months before, on June 17 in that same year.

Looking above his accusers at the clear glorious sky or around at the faces of the hostile crowd, the accused might well have felt his heart fail at this bitterest thought of all — his book was burned. No one would ever read in centuries to come his great exposition of the unity of God.

Did he know of the four or five copies of his book which had been abstracted from the bales in which the printer bound them and which

would eventually be preserved as among the rarest and most precious volumes in the world? Probably not. The bitterness of his cup had little to sweeten it. Of course he had sent one copy to John Calvin, with a curiously innocent faith in the fair-mindedness of that deeply theological fanatic. That copy was the text used for the long questioning he had undergone before the tribunal. But it was to be burned along

Medicine's great Martyr — Michael Servetus. He described the course of the blood through the lungs from the right to the left side of the heart.

with his own body. So every memory of Michael Servetus would disappear from the earth.

"These and other causes moving us," concluded the sentence, "desiring to purge the Church of God of such infection and to cut off from it so rotten a member, we, sitting as a judicial tribunal in the seat of our ancestors — "

All done with the highest motives, of course.

"In the name of the Father, Son, and Holy Ghost—"

The heads of the populace bow. Some of the older ones, not quite liberated from old custom, abstractedly cross themselves.

"We condemn thee, Michael Servetus, to be bound and taken to Champel, and then, being fastened to a stake, to be burned alive, along with thy books, printed as well as written by thy hand, until thy body be reduced to ashes."

A member of the tribunal stepped forward and broke the staff over the prisoner's head, according to custom, and then there was a long silence in the square.

It was ended by Servetus himself, on whom the terrible sentence had just been pronounced. He did not ask for reversal of the award, but only that its manner might be modified.

"I fear," he said, "that through excess of suffering I may prove faithless to myself and belie the convictions of my life. If I have erred, it was in ignorance; I am so constituted mentally and morally to desire the glory of God."

But he must have known the appeal would be in vain. John Calvin himself, when the court had decreed death, had attempted to have sentence carried out by beheading with the sword, the usual way in criminal cases. John Calvin did not care to invite comparison with Rome in its method of dealing with heretics. But the council, before whom Servetus now stood, overruled these views. The Canon Law condemned the convicted heretic to death by fire. The council decided to stand by the statute.

Plucking him by the sleeve, the stern-faced Farel, Calvin's mentor and familiar, indicated that they should begin their march towards the place of execution.

The Lieutenant Criminel and other officers on horseback preceded them, a guard of archers surrounding the prisoner and Farel, who continued to admonish him to acknowledge his errors and renounce them.

"Is there no word on your mouth but the name of God?" asked Farel.

"On whom can I now call but on God?" replied his victim.

When they reached Champel, the hill of execution, and came in sight of the pile of faggots, Servetus fell to the ground and for a time was absorbed in prayer. Rising, he delivered himself into the hands of the executioner, who had him sit on a block, his feet just reaching

the ground. His neck was bound to the stake with a rope, his body by several turns of an iron chain.

Two books, one the manuscript copy of the *Christianismi restitutio* which he had sent to Calvin six years before, and the other, one of the printed copies of the Vienne edition of the same work, were fastened to his waist that they, his doctrines, might burn with him.

A chaplet of straw and green twigs was placed encircling his head, bestrewed with brimstone. This was a mockery.

Then the torch was applied to the faggots and flashed in his face. The brimstone blazed. A great cry of agony was wrung from him, and then he was silent, brave, dignified, and contemptuous.

The wood was purposely green, that his sufferings might be prolonged. Some of the people helped the executioner in heaping faggots on the fire. But it was a long half-hour before signs of life were extinct in him. The green wood crackled and hissed. Michael Servetus and his doctrines were reduced to a charred mass.

By some hook or crook three copies of that book on the Restitution of Christianity escaped the fire. One reposes now in the National Library at Paris, another in the Imperial and Royal Library in Vienna, and a third and mutilated one at Edinburgh. They are frequently visited by reverent scholars. But, curiously, the reverent scholars are not reverends. No theologian today bothers with the tortured doctrines of Servetus. I doubt if a pure theologian — even if some such monstrosity still roams the earth — has read a line of the *Christianismi restitutio* for two hundred years. No! The reverent scholars are humble doctors of medicine and they pay their homage to Servetus' book because it first definitely described the flow of the blood from the right side of the heart through the lungs back to the left side of the heart. That is to say, it first definitely described the pulmonary circulation.

It was not for this that Michael Servetus suffered torture at the stake, however. Reading through all the questions and arguments at that trial for heresy in Geneva, I can find no place where any of the learned doctors even referred to the passages which alone today give the work any value.

That Servetus should have included this piece of physiological speculation in a treatise on theology is natural enough, considering the intellectual temper of the time. The majority of intellectuals were more interested in theology than in anything else. But it was a time of fer-

ment, and the old doctrines were discussed in the light of the new learning, and with the new freedom of the Reformation — Luther had pinned his thesis on the door of the church at Wittenberg in 1517. All over Europe national literatures, discarding the Latin of the pedants, were springing up. Rabelais, a theologian, published *Pantagruel* in native French in 1532. The new astronomy had rejected the flat world of the old theology. No theologian could afford to be ignorant of the new developments in science.

Servetus was led naturally, therefore, in discussing the unity of God, to consider man's body. He thought the " vital spirit " which came from God and was inherent in all his human children was inherent in the heart and arterial blood. The " natural spirit " is associated with the darker, venous blood and the liver. This, you see, is Galen, modified by theology. But the distinction between venous blood and arterial blood is clearer than Galen.

" The vital spirit," continues Servetus, launching into his great description, " has, therefore, its source in the left ventricle of the heart, the lungs aiding most essentially in its production. It is a fine attenuated spirit, of a crimson colour and fiery potency, for it is engendered, as said, by the mingling of the inspired air with the more subtle portion of the blood which the right ventricle of the heart communicates to the left. This communication, however, does not take place through the septum, partition, or midwall of the heart, as commonly believed " (this the refutation of Galen's holes in the septum between the two sides of the heart), " but by another admirable contrivance, the blood being transmitted through the lungs, in the course of which it is elaborated and becomes of a crimson colour. Mingled with the inspired air in this passage, and freed from fuliginous vapours by the act of expiration, the blood becomes the fit dwelling-place of the vital spirit; it is finally attracted by the diastole, and reaches the left ventricle of the heart.

" It is not simply air, but air mingled with blood that is returned from the lungs to the heart by the pulmonary vein.

" It is in the lungs, consequently, that the mixture (of the inspired air with the blood) takes place, and it is in the lungs also, not in the heart, that the crimson colour of the blood is acquired."

This, as anyone can see, is a very clear account of the movement of the blood from the right side of the heart, through the lungs, to the

left side of the heart. Not through the septal openings of Galen. Further, of its change from a dark to a light red colour, due to the mixture of the blood with air in the lungs.

It is probable that William Harvey never saw this description. It was not until 1694 that Dr. William Wotton called attention to it and it became generally known.

Young William Harvey was, from the outset of his medical studies, fascinated by the problem of the heart and blood-vessels. He must have been considerably mixed up by what he was taught.

Here was his teacher Fabricius, who had discovered that the veins had little valves in them — all through their courses. The valves are so placed that they obviously keep the blood from flowing out to the extremities, as Galen said it did. And yet Fabricius, with the refutation of that fact staring him in the face, got himself hopelessly intricated in a theory — he taught that the valves were in the veins to prevent the blood from flowing out to the extremities too rapidly: they allowed only as much as is needed to get there.

An anatomist named Realdus Columbus stated very clearly the actual facts about the vexed question of the blood-flow through the lungs. He probably stole or plagiarized it from Servetus, but it is in the book he published in 1559, from which he taught as Professor of Anatomy in this same University of Padua. Young Harvey must have heard something of that doctrine.

Then there was one Cesalpinus who taught at Pisa, just before Harvey's student days. He had a vague idea of the circulation of the blood, much mixed up with philosophic theories, and based on reason, not experiment.

When Harvey returned to England, in 1602, his mind was full of the perplexities of the problem. He settled in practice in London and was licensed by the College of Physicians.

In 1615 he was appointed Lumelian Lecturer on Anatomy at the Royal College of Surgeons. On April 16, 17, and 18, 1616 he gave his first course of lectures on the internal organs. It was quite a month for England. The next week — on April 23, William Shakspere, a gent and a play-actor, died of too much hard liquor at Stratford-on-Avon.

"After all, what can I learn from *dead* bodies?" the thought occurred to Harvey, the young professor. "The life, the movement of the blood, has gone out from them."

Here was a step forward from Vesalius. Galen had dissected dead animal bodies. Vesalius had improved knowledge by dissecting dead human bodies. Now Harvey wanted to see the inside of living bodies.

Of course, he could not use living human bodies. But he began to use living animal bodies — snakes and fish at first.

He dissected out an artery and put a small ligature around it. Then he made a nick in it on the side towards the heart. At each heart-beat blood spurted out from the artery. Gradually less and less blood spurted. The heart flagged. "Why was that?" he asked. Wasn't it because no more blood came back to the heart? If Galen's theory were correct, the liver would manufacture blood, and a continuous supply would keep up.

To complete this experiment, he tied the large blood-vessel coming from the heart in a snake and nicked an opening in it on the side away from the heart. No blood flowed. But in a few seconds the heart swelled to bursting with the engorgement of the blood which entered it from the lungs and other parts of the body. Finally all the animal's blood had accumulated in the heart.

Then he tied a constriction around a human arm. The veins swelled out and the little nodules, each of which marked the site of a valve in the vein, could be seen just as his teacher Fabricius so often demonstrated. But Harvey now went further. He milked the blood out of the veins towards the heart, starting exactly where a valve was located. Very rapidly the blood came up *from the extremity towards the heart* and filled the vein again.

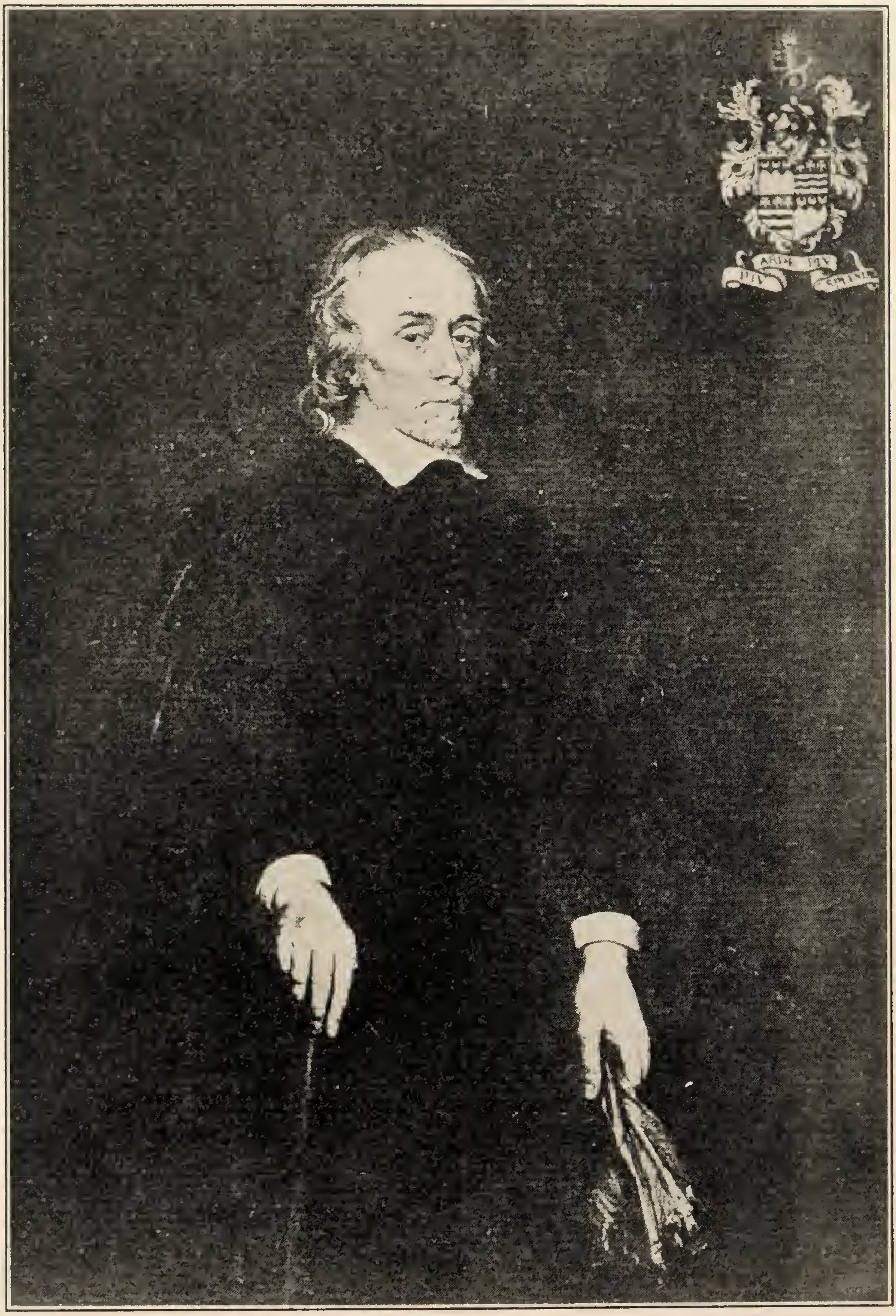
Then he did something quite ingenious. He put his finger on a superficial vein in a man's arm, and with the other finger milked all the blood out of the vein towards the heart. Then he lifted the finger nearest the heart. No blood came into the vein. The valves held it back. Then he lifted the finger where he had originally compressed the vein. The blood filled the vein, coming up from the extremity towards the heart.

What had he proved by these experiments?

First, that blood flowed out from the heart in the arteries.

Second, that blood flowed towards the heart in the veins.

And, thirdly, by inference, that all the blood in the body was constantly moving in a circle. From the left heart, out through the arteries, into the veins, back to the right heart.



William Harvey. He proved experimentally the circulation of the blood. 1628.

Then came the question: how did it get from the right heart to the left heart? He proved that Galen and Vesalius were wrong about those openings in the septum. They simply did not exist. There is no direct communication in normal hearts from the right to the left ventricle.

"Well, there is a plain path," said Harvey, just as Servetus had, "for the blood to travel — from the right ventricle out through the pulmonary artery to the lungs, through the lungs, emptying into the pulmonary vein, which returns the blood to the left side of the heart. There is a valve at the opening of the pulmonary artery which prevents the blood from returning to the heart once it enters the artery. There is only one place for the blood to go — through the lungs."

He stewed and thought and experimented and lectured on these ideas. As early as 1616 his lecture notes are found to contain the following:

"W. H. demonstrates by the structure of the heart that blood is continually passed through the lungs into the aorta as by two clacks of a water bellows to raise water. The passage of blood from arteries to veins is shown by means of a ligature. So it is proved that a continual movement of the blood in a circle is caused by the beat of the heart."

Then he made the great final experiment. It was conceived reasonably and logically.

"How much," he wondered to himself one day, "how much blood does the heart eject in one beat?"

"Not more than the size or contents of the ventricles," was the obvious answer.

"How often does the ventricle eject this amount?"

"Seventy-two times a minute" (that is, the rate of the pulse).

"All right, let us measure the size of a ventricle."

He killed a sheep and took out its heart. He poured water into its ventricle. It held about two ounces. A man's is about the same. Very well, then, if it beats seventy-two times a minute, it will force out about three and a half pounds of blood in that time.

But now let us see how much blood there is in the body. He tried it on a sheep, bled it of every drop — only four pounds. The experiment was complete. If the heart continues to force out blood at the rate of three and a half pounds an hour, and there are only four pounds of blood in the body, there is not enough new blood for the heart to work on; the blood *must* return to the heart again.

It moves in a circle.

In 1628, a little over three hundred years ago, there appeared the announcement of these experiments and a clear statement of the conclusion to which they led.

Exercitatio anatomica de motu cordis et sanguinis in animalibus is the name of his book — *Anatomical Experiments on the Motion of the Heart and Blood in Animals* — by William Harvey; printed at Frankfurt. Only a few copies exist today.

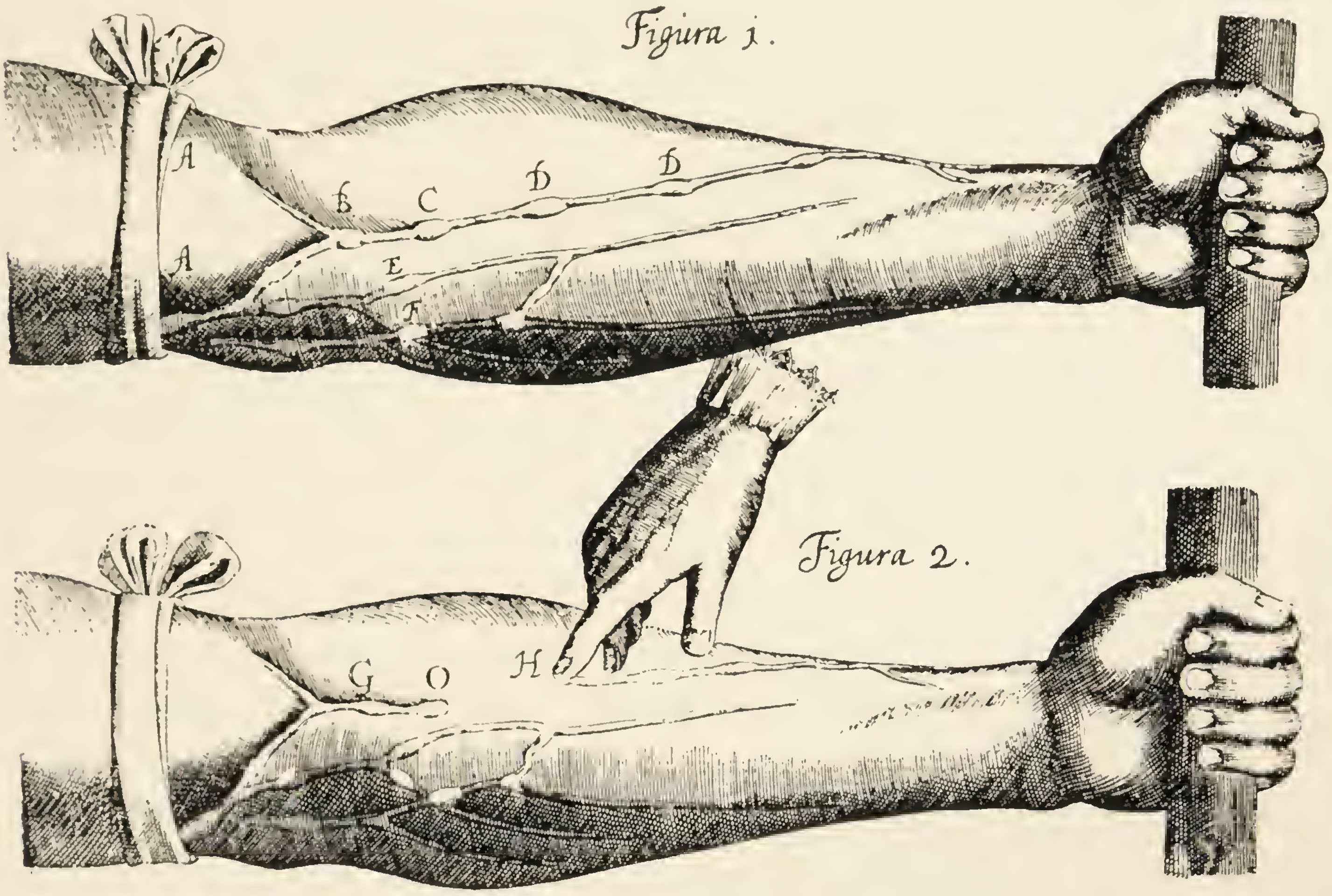


Figure of the venous circulation in Harvey's book On the Motion of the Heart and Blood. *This figure demonstrates that the blood in the veins flows towards the heart. The upper figure shows that if a tourniquet is placed about the arm, the blood will distend the veins on the side away from the heart. The enlargements,* B, C, D, E, F, *in the course of the vein indicate the sites of valves. The lower figure shows that if a vein is stripped beyond a valve towards the heart, the blood will not flow backwards, but is held by the valve in the vein at* O.

It would be difficult to over-estimate the influence of this book. It did one of the most difficult things in the world — it pulled men's minds out of a groove of thought. Even such an original as Vesalius was in that groove.

Sober scholars have called it the greatest book that ever was written. Certainly only the *Fabrica* of Vesalius challenges its right to be called the greatest of medical books.

Its importance lies first in the fact that a realization of the circulation of the blood unifies one's conception of the functions of the animal body.

All those functions depend upon a circulating fluid or medium of exchange. The stomach and intestines digest food, and the *circulation of the blood* carries this nutriment to the whole body. The muscles and other organs throw their waste products into the blood-stream, and the *circulation of the blood* carries them to the lungs and kidneys to be cast off. As it passes through the lungs, the blood picks up the necessary vital elements from the air to distribute to all parts.

Thus, you see, this conception opened the way for knowledge of the functions of the stomach, the liver, the lungs, the kidneys, and the muscles.

In surgery, too, its effect was fundamental. The first great problem of surgery is the control of hæmorrhage. Whenever the surgeon cuts into the body, there is bleeding, and if he cannot control this, the patient will die and the operation might as well not have been performed. And no control of hæmorrhage can be anything but bungling unless the mechanics of the circulation are understood.

In obstetrics, too — the knowledge of the method of the development of children — there came light. One of the great problems, a subject for debate before Harvey, was what the afterbirth, that big spongy red mass attached to the baby by a cord, actually did. In 1667 Walter Needham showed that it communicated with the mother's blood and furnished nourishment to the developing fœtus.

Only secondary in importance to the actual proof of the circulation of the blood was the way Harvey demonstrated it. Not by theory or reason, but by experiment on animals. For ever after men were to be forced to go to the book of nature, not to authority, if they were to be sure of nature's ways. Everything he says and does is experimental, not mouthing.

" In fishes, also, if the blood vessel leading from the heart to the gills is cut open, the blood will be seen to spurt out when the heart contracts." Experiment on a living animal.

Or: " I once had a patient which convinced me of this truth." Observation of nature.

Or: " In a Hen's egg I shewd the first beginning of the Chick like a little cloud, by putting an egg off which the shell was taken, into water warm and clear, in the midst of which cloud there was a point

of blood which did beat, so little, that when it was contracted it disappeared and vanished out of our sight, and in its dilation, shewd itself red and small, as the point of a needle . . . it did represent a beating and the beginning of life." Experiment and observation combined.

The significance of this greatest discovery in the record of medical science became evident as time went on, but at first, although the work was widely read, it gained no adherents from any of the established anatomists of Europe. When recognition did come, it was from the younger men. Solemn worthies wrote weighty objections. To none of these did Harvey reply until Joannes Riolan, Professor of Anatomy at Paris, published a refutation. Then Harvey's fighting blood was up, and in 1649 he published his two replies to Riolan. They were an extension and explanation of the earlier book and they demolished Riolan and all the rest of the opposition.

There was, it must be acknowledged, one point in his doctrine which did not admit of clear demonstration in his own day and was a logical point of attack for critics. That was the query: *How does the blood get from the arteries to the veins?* It goes out from the left heart in the arteries, and back to the right heart in the veins, but no connexions could be made out between the arteries and veins. Harvey admits this freely. "I have never succeeded in tracing any connection between the arteries and veins by a direct anastomosis of their orifices." He supposed the blood from the arteries flowed out into the tissue spaces and that the veins, opening with hungry mouths into the same spaces, drank it up.

As we know today, the connexion is made by the capillaries — those minute thin-walled vessels which can be seen only by a microscope. But Harvey had no microscope.

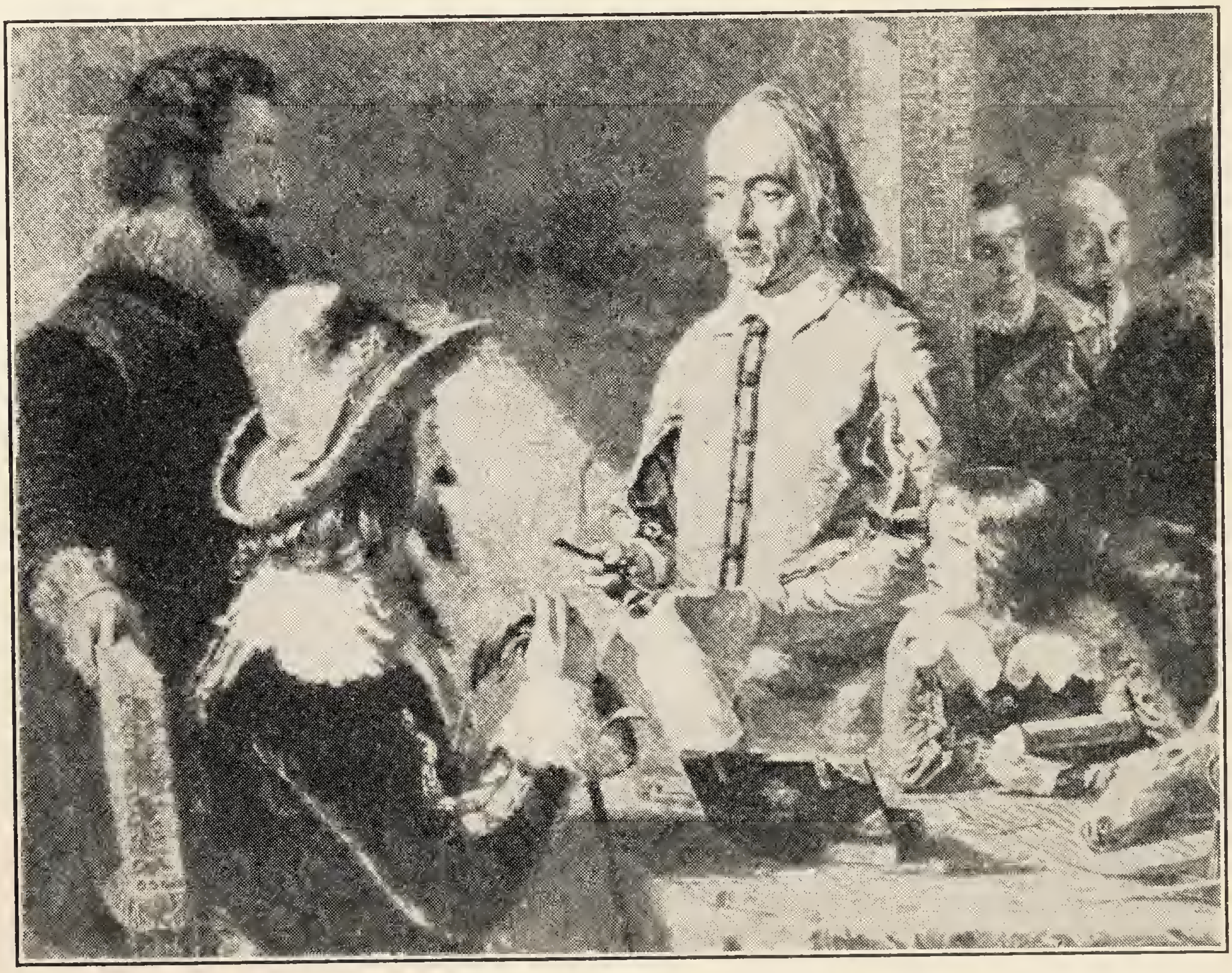
In 1660, three years after Harvey's death, Marcello Malpighi with one of the early crude microscopes saw among the "so many marvels of nature spread before my eyes," when he placed the lung of a frog opposite his microscope lens and turned the instrument "against the horizontal sun," the blood-cells passing from the small arteries through ever smaller but definite channels (the capillaries) to the widening slower stream of the veins. But this is described in the next chapter.

By the middle of the seventeenth century the doctrine of the circulation of the blood was generally accepted. "He is the only man per-

haps," wrote Mr. Hobbes, "that ever lived to see his doctrine established in his lifetime."

He was fifty when this, his most important book, was published.

After this, Harvey's life went on about thirty years. It was a period crowded with external incident, but little inner fruitfulness. He went on divers journeys on the Continent; he was, at least partly, instrumental in saving the lives of some miserable old women in Lancashire, accused of being witches; he examined after death the body of the aged



Harvey demonstrating his experiments to King Charles I.

Thomas Parr — "old Parr" — who was said to have been a hundred and fifty-two at the time of his death; he accompanied his royal master, Charles I, to his wars, sat under a tree at the Battle of Edgehill, in charge of the two little princes, until it was time for him to dress the wounds of the soldiers. After Charles was beheaded, in 1650, he was found by a friend "busy with the study of natural things," although he avowed affairs could not be well with him "whilst the Commonwealth is full of distractions and I myself am still in the open sea."

In 1651, a year after King Charles's execution, he published his second

book *Exercitationes de generatione animalium* — " Studies on the generation of animals." In its way and in its field it has an importance only second to the treatise on the circulation. It controverted the mediæval idea of the growth of an animal in the egg — that of the animalculum — that in the very beginning an animal was a tiny, but exact, replica of the adult, and during the process of development simply enlarged in the egg. Harvey showed that it went through stages of development in which its form changed and gradually approached the final structure of the animal at birth. Thus he was the founder of modern embryology, " the father of English midwifery."

Here, as in the demonstration of the circulation of the blood, he was stopped from the final proof by the lack of a microscope, without which he was unable to see the very earliest stage of the embryo.

For many years he must have been a familiar figure in the streets of London — busy with his practice, with his lectures at the Royal College of Physicians. He was a small-statured, bad-tempered, choleric little man, 'tis said. Like most persons of sense, he did not suffer fools gladly, and favoured many people with extremely short answers.

Among these must be reckoned that great philosopher who is thought by some to be the author of Shakspere, Lord Chancellor Bacon. Harvey attended him in a professional capacity. He would not allow him to be a great philosopher, his biographer, Aubrey, tells us. " He writes philosophy like a Lord Chancellor," he said, adding: " I have cured him."

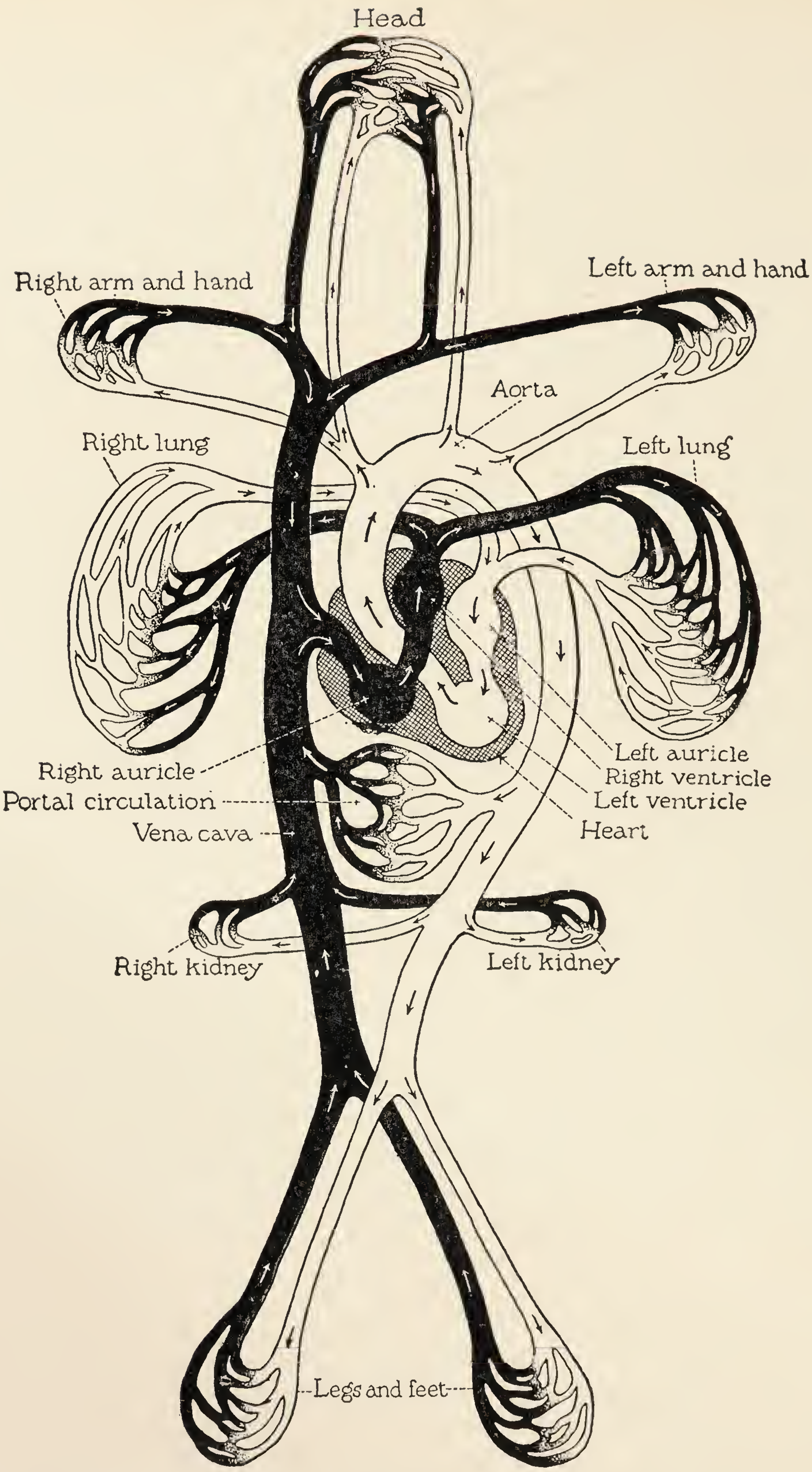
He gave it as his mature opinion that man was but a great mischievous baboon.

" After his book on the Circulation of the Blood came out he fell mightily in his practice and 'twas believed by the vulgar that he was crack brained."

He drank coffee before there were coffee-houses in London. He kept a " pretty young wenche to wayte on him," says Aubrey, the gossip, " which I guess he made use of for warmeth sake as King David did, and took care of her in his will."

He was wont to refer to his rivals and opponents of his views as " shitt-breeches." He had a parrot which he thought was a male until it died. Then the " father of English midwifery " dissected it and found it was a female.

He had the pain of seeing his country in the toils of civil strife. Through it all he remained loyal to his King. He must often have met



The true course of the circulation of the blood, which was established by William Harvey by means of experiment. *Compare with Galen's ideas. The arterial blood is forced by the left ventricle of the heart into all the tissues. After entering the veins it returns to the right side of the heart and is forced by the right ventricle through the lungs, where it becomes aerated or changed to arterial blood and returns to the left side of the heart, and the circle is again begun.* (*Figure from the author's book* The Human Body)

General Cromwell in his rounds, and we may imagine the contemptuous pride with which he strutted past him. Indeed, the Commonwealth troopers broke into his rooms in Whitehall once and destroyed many drawings and descriptions of experiments. But Dr. Harvey was too useful a man for the Protector, generous hater that he was, to put under any personal humiliation or inconvenience. He may, though we have no record of it, have been consulted about Mr. Milton's approaching blindness. It is not impossible that he was consulted by young Master Samuel Pepys for the symptoms which eventually turned out to be caused by those stones in the bladder which so interested Mr. Pepys all his life. It is very likely, since they were of the same political complexion, that he attended Richard Lovelace and Sir John Suckling.

So in this busy, fussy sort of existence he went on to his seventy-ninth year, when one morning he woke to find his tongue palsied. He made a sign to the apothecary who was sent for, to bleed him from a vein under the tongue, but happily his misery was short and that night he died. "Lapt in lead" (in a mummy case of lead), he was laid to rest in Hempstead Church, Essex, June 26, 1657.

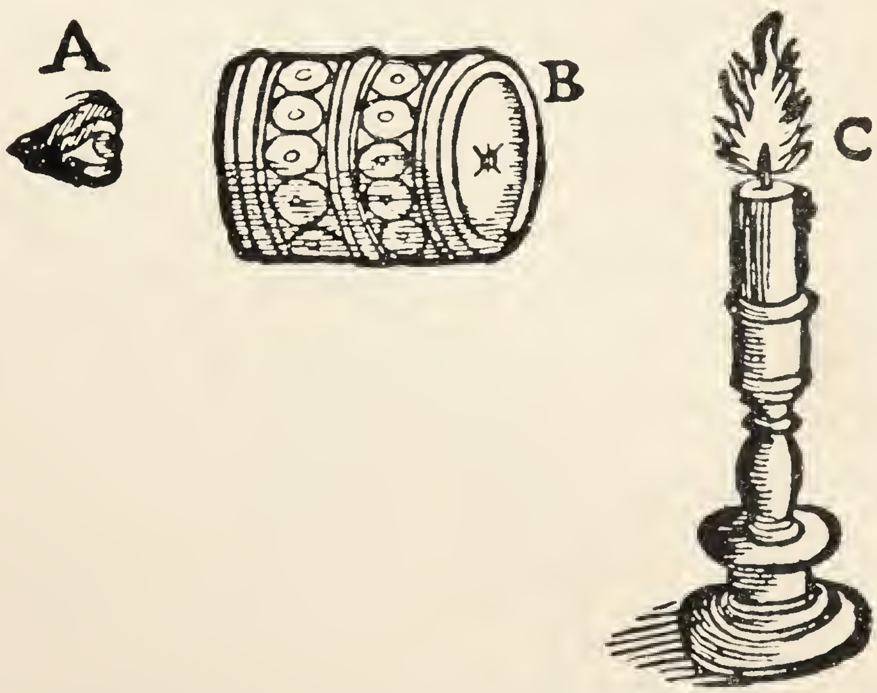
CHAPTER VII

THE MICROSCOPE

1. *The Small World of Life*

There are no fleas in my kitchen."

When a thrifty Dutch mother enters her own kitchen unexpectedly to find her husband and her son on their hands and knees picking into cracks with pins, she has a right to her surprise. And to be told, after a civil question, that they were looking for fleas was a little too much for



The first microscope. One of the "flea glasses" of the Janssens. Zahm, 1685.

a woman whose whole life was devoted to maintaining an ideal of spotless cleanliness.

But her son and husband continued their search regardless of her protests.

"Hans Janssen, get up off your knees this instant — are you not old

enough to know better? What do you mean by this nonsense? I tell you there are no fleas in my kitchen."

"Now, my dear — calm yourself — yes, there are fleas in the kitchen."

"There are not. How dare you say there are fleas in my kitchen?"

At this the son, Zachariah, began to laugh and held up his needle. On it was impaled a little black speck.

"I have found a flea in your kitchen," he announced, solemnly.

"How did you know there were fleas in my kitchen?" asked the housekeeper, now more alarmed about her reputation for orderliness than angry.

Her husband rose and, dusting his knees, faced her in full repossession of his authority.

"Because," he said, "I brought them here."

"You!" The good woman's face began to get red. "You brought fleas into *my* kitchen — you —"

"Now, now, mine little mother, look at this," said Zachariah. And he held up for her inspection a queer little metal frame, putting the needle with the impaled flea inside.

"Put your eye to that," he commanded, and she saw there was a little piece of glass fixed into the metal.

She looked through this and then drew back in alarm. She was face to face with a terrifying monster. The flea had become enormous, grotesque — a great bulbous belly with heavy, gruesome, rapidly moving legs attached. Long, wiry hairs covered the armour-like cuirass.

Frau Janssen pulled her head around to see how this fearful object would look without the little glass in the metal. It was hardly recognizable, merely a black speck on the end of the needle. One could, now that one's eyes were educated, see minute twitchings of the legs. She glued her eye to the glass again, and, sure enough, the creature assumed its former terrifying proportions.

"So that's a flea!" she exclaimed with an awe-inspired inrush of breath.

"That is a flea, little mother," said the son.

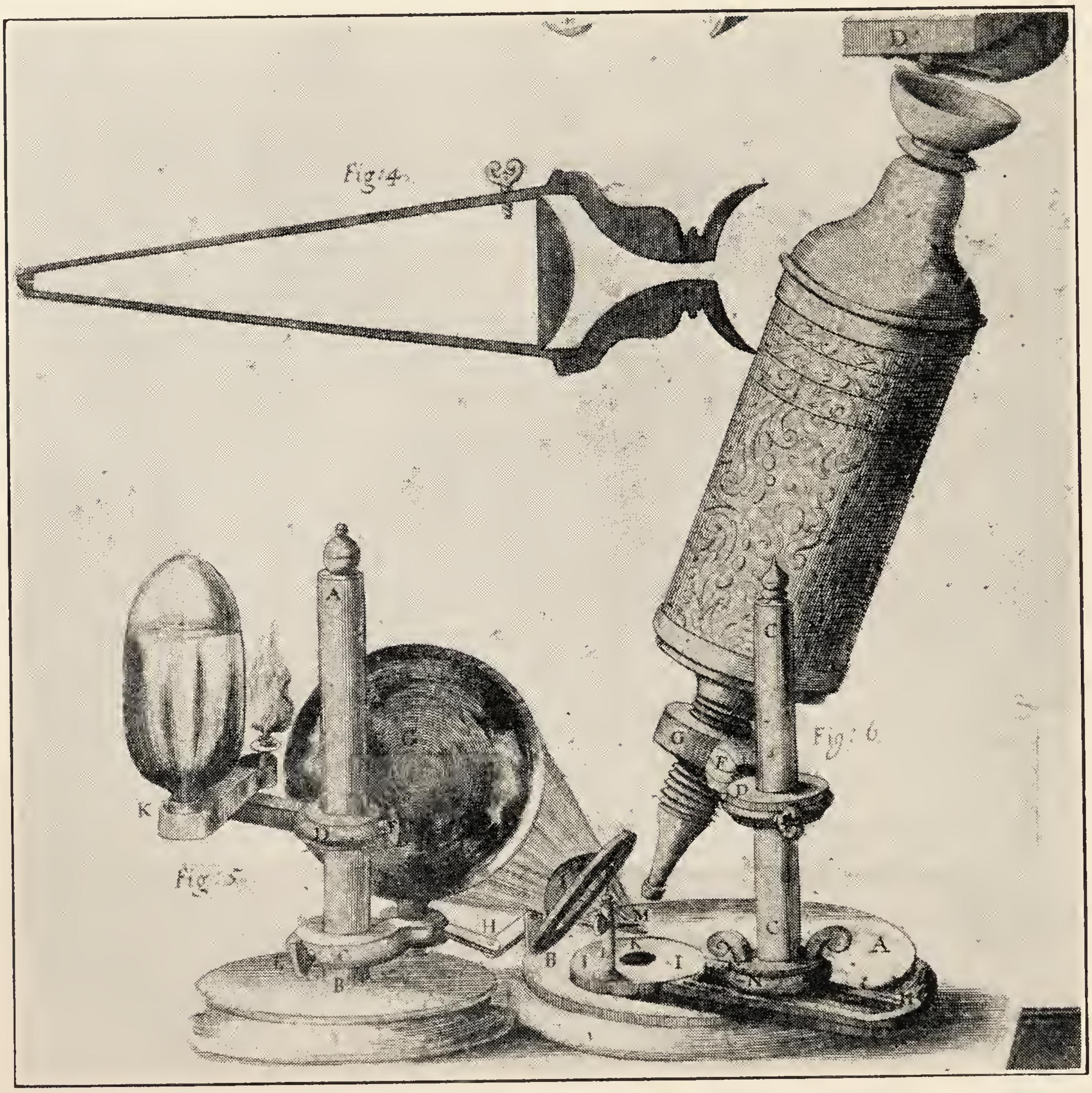
"And did you make this?" she asked, tapping the metal frame.

"Father and I together have been making some," her son answered.

Hans Janssen had been a spectacle-maker and had brought his son up as an apprentice in his trade. In Holland the grinding trades — diamonds and glass — were, and still are, staple industries.

It was in 1590 that they began to make their "flea glasses." Their skill with spectacles suggested the idea. They made glasses so that old people who couldn't see any small object had good sight restored to them.

Then they thought of glasses so powerful that they would be perfectly useless for ordinary purposes of reading or sewing or working, but



Improvement in the microscope. Hooke's instrument. (*From* Micrographia, *1667*)

might magnify objects which could hardly be seen at all with the unaided eye. Thus their first flea glasses were made. They were considered toys at first.

But within a generation these toys were to open a new world to man's vision and prepare the way for one of his greatest conquests. For the flea glasses of the Janssens contained the germ of the microscope.

The early flea glasses magnified, probably, ten times. But the Dutch are skilful and ingenious artisans, and before long, improvements were being made. In 1632 there was born at Delft a boy baby who was endowed with the staggering appellation of Antonj van Leeuwenhoek. And almost at the same time, in 1637, there was born in Amsterdam a boy baby, Jan Swammerdam. These men were to make models of miscroscopes which magnified two hundred and three hundred times. With curious contemporaneousness an English boy was born in 1635, Robert Hooke, who was endowed with mechanical genius and an exceptionally irritable disposition, and who was the first of these to produce a microscope at all resembling our modern instruments. And more important than all for medical science in those sixteen-twenties and thirties, there was born near the high, towered city of Bologna in 1628 an Italian boy, Marcello Malpighi, who was to turn all these instruments from playthings into serious weapons of science.

A Jesuit priest — a mathematician, musician, physicist, optician, archæologist, and physician — Athanasius Kircher, has the honour of being the first to apply the microscope to the human body in disease. In 1658 he claimed that he found the blood of plague patients was full of small worms, which could not be seen by the naked eye, but could be seen under his crystal glass. These were certainly not pest germs, as Kircher's glass was not powerful enough to see germs of any kind — they were probably rouleaux of red blood-cells. But the application of the toy to something useful was established.

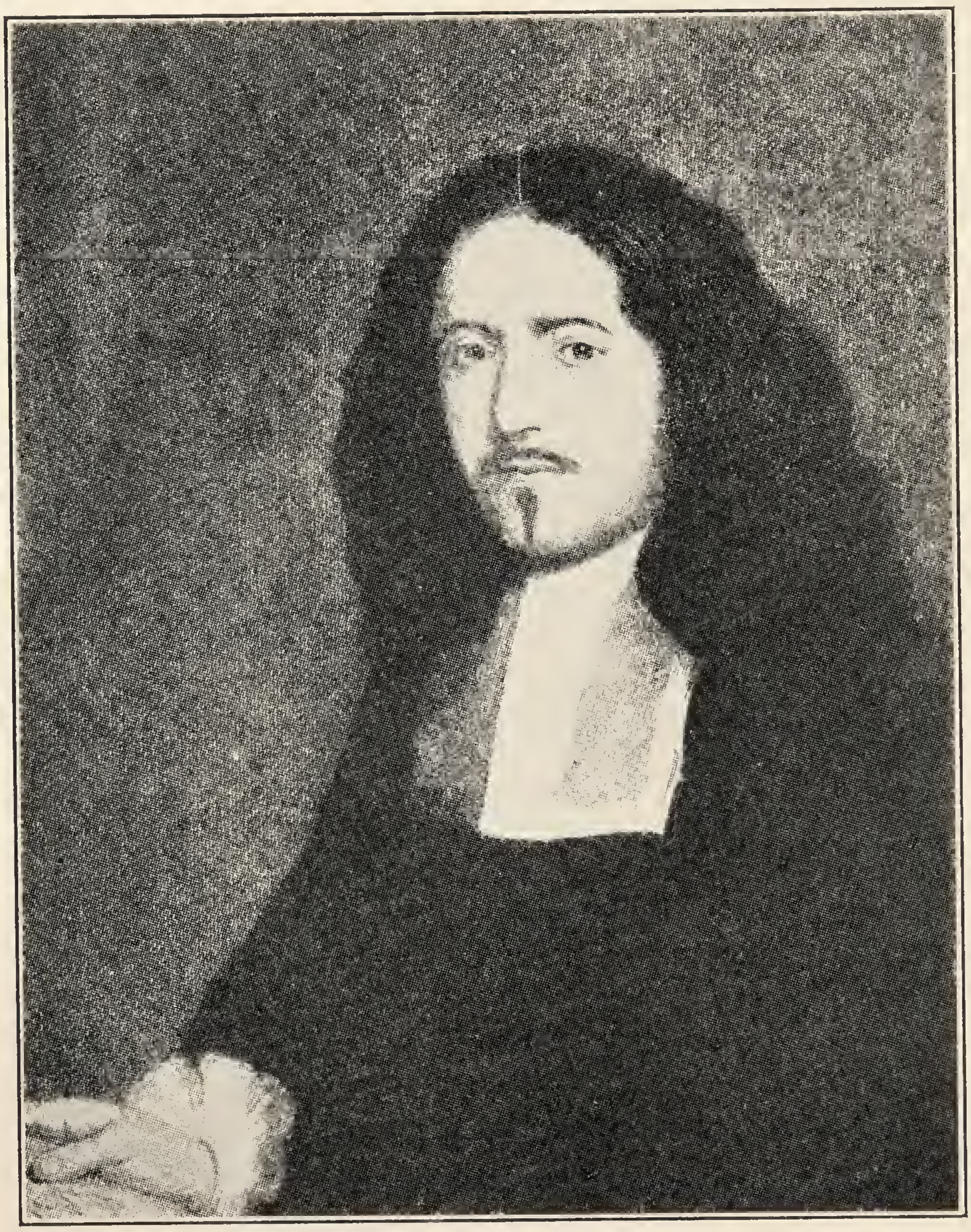
"If," wondered Antonj van Leeuwenhoek at Delft, "a flea looks so confoundedly different under a glass, I wonder how would the transparent tail of an eel look." And he devised a special kind of microscope to find out.

"If," wondered Jan Swammerdam at Amsterdam, "a small bug has so many things on it I can't see with my naked eye, how would the inside of a worm look under a glass?" And he started to find out by making glass tubes as fine as hairs with which to dissect out the delicate internal organs of worms and caterpillars.

"If," wondered Robert Hooke, "the damned robbers who are trying to claim all the ideas I have ever had have been able to see what they claim, and which the lying swine probably haven't seen, I wonder why I can't shave minerals and plants very fine and see something remarkable before the other accursed swindlers see them." So, with this

charitable objective, he followed his bent, and in finding " little boxes or cells, distinct from one another," in plant stems he nearly anticipated the cell theory of Schleiden two hundred years later.

And, finally, the most important for our purposes — " If," mused gentle Marcello Malpighi at Pisa, where he had been called to occupy a chair at the university, " all these little things can be seen by look-



Marcello Malpighi (1628–94), the greatest of the early microscopists. He discovered the capillaries and described the minute structure of the lungs, kidneys, and spleen.

ing at a little animal, maybe if I looked at a kidney or a lung — organs which looked like a single thing to Vesalius and Eustachius — I could find that they, too, were made up of little parts too small to be seen by my naked eye." And he began to see how much truth there was in this idea.

So the world learned from Leeuwenhoek that there were striations across muscle tissue, which allowed one to distinguish it from any other tissue. And the world learned from Leeuwenhoek that if you scrape your teeth and gums and put these scrapings in a drop of water under the microscope, millions of moving little animalcules can be seen. And that even drops of water have these little organisms in them. Leeuwenhoek made hundreds of microscopes himself, each one adapted to its own purpose. He made one to show the tail of an eel, and another to show little animals in water, and another to show unborn oysters — we have pictures of many of these which he drew for his reports to the Royal Society.

Swammerdam found on looking at blood that it was not a homogeneous liquid, but that it was composed of little round globules floating in a serous liquid. He had the honour of discovering the red blood-cells.

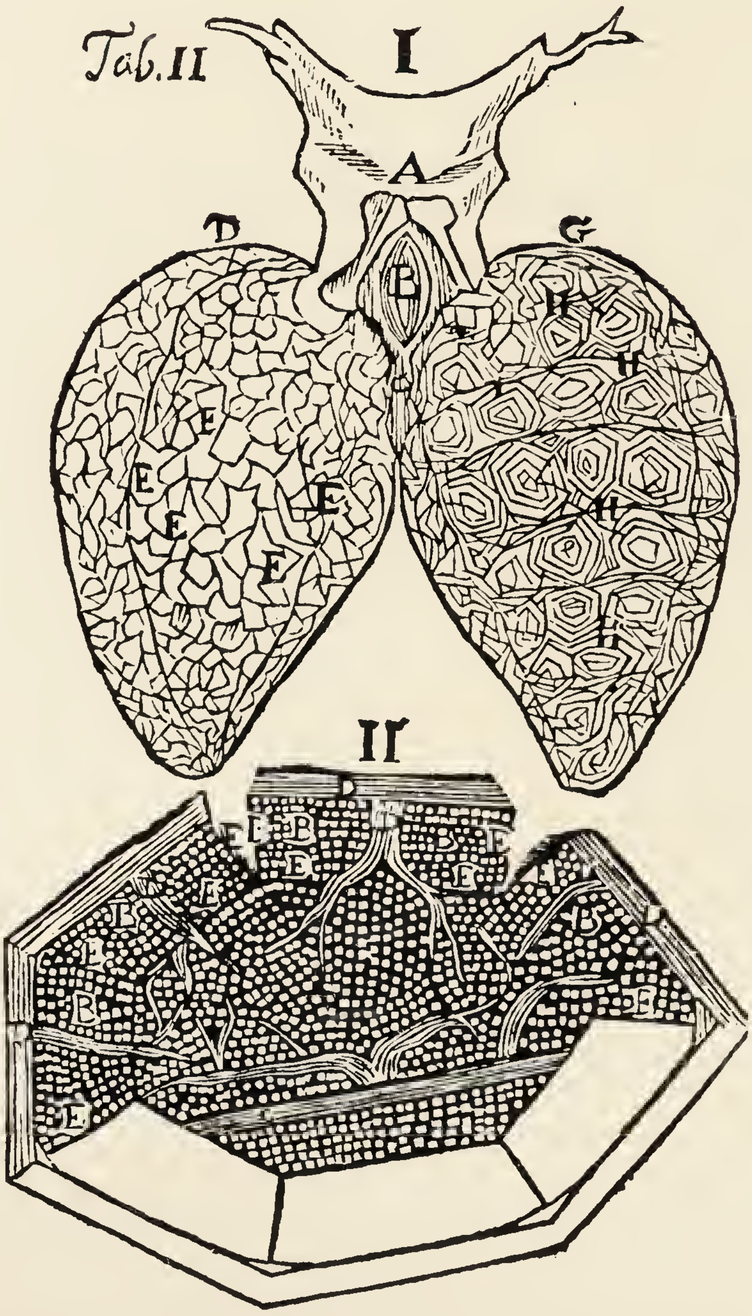
Malpighi's investigation of such organs as the lungs and kidneys made him, after Vesalius, the greatest anatomist who ever lived. The usual idea was that the lungs were "fleshlike," or, in other words, parenchymatous; that they were like solid glands, that they secreted something. But Malpighi thought they felt more vesicular; that they were spongy. The curious thing about all these discoveries was that they depended simply on using one's eyes and senses and refusing to accept pompous authority. Parenchymatous, indeed! Why, the lungs didn't look or feel parenchymatous: they looked as if they were filled with air.

So Malpighi tried it. He removed a pair of lungs from an animal and put a tube in the windpipe and blew them up. Then he dried them in that state. He proved that they were vesicular — made up of numerous little pockets into which the air penetrates. He found that he could trace one of the air tubules from the big windpipe itself down to smaller and smaller branchings, until finally he came to a little open space, a sort of sac made up of thin membranous walls.

Malpighi did not know what this sac and the air did exactly. I think he wondered all his life why air went into the lungs — what it did when it got there. Nobody had yet discovered oxygen. Nobody knew the air contained oxygen. Nobody knew that oxygen turned black blood red, and that red blood carrying oxygen gave energy to all parts of the body.

But Malpighi kept turning the problem over in his mind. He knew

that the lungs had a good deal of blood coming into them and then he saw that around every air sac there was a plexus of blood-vessels. "Perhaps," he thought, "the lung does something to the blood which keeps it from coagulating." He knew the blood when it runs out of a



Malpighi's illustrations to show the existence of capillaries — connexions between the arterial and the venous system — in the lungs of the frog. This was the final step in the proof of the circulation of the blood. To the left above is the outside surface of the lung, showing the network of capillaries. To the right the lung has been laid open, showing the capillaries of the lung-sac. The figure below represents a cross-section of the lung.

vein jellies into the mass we call a coagulum. Why doesn't it do that in the body? Malpighi's idea was that the lungs prevented this.[1]

So he was led to study this plexus of blood-vessels around the lung-sac,

[1] The conception was of course entirely erroneous.

and this opened up the way to answering the great question Harvey left unsettled. Harvey proved beyond all doubt that the blood travelled in a circle. He proved the blood left the heart by way of the arteries, and he proved it returned by way of the veins. How did it get from the arteries to the veins? His perplexities have been described in the previous chapter. Harvey could dissect an artery from a big trunk until it got into smaller and smaller branches and finally he lost it. Then he could pick up a little needle-sized vein emerging apparently from solid flesh and follow it up towards the heart as it got larger and larger. But what was in between where he lost the artery and picked up the vein? Harvey couldn't tell, because he had only his unaided eyes.

But in studying lung preparations under his glasses, Malpighi saw arteries coming in and breaking up into finer and finer channels until they got as fine as hairs. So he called them capillaries. Then these capillaries began to get larger and larger until they turned into veins. So the connexion between the arteries and the veins was finally made out — the capillaries. "Harvey made their existence a logical necessity. Malpighi made it a histological certainty." Malpighi's great discoveries did not stop with the demonstration of the capillaries. He made out the microscopic anatomy of most of the internal organs.

Think for a moment of what the ancients had thought about the kidneys. Aristotle, the darling of the Middle Ages, taught that the bladder was the chief site of urine formation, and that the kidneys were attached to it " not of actual necessity, but as a matter of greater finish and perfection." Vesalius did not do much better. Two anatomists contemporary with Malpighi, Borelli and Highmore, did correct this absurd opinion, and Malpighi wrote: "The constant trickle of urine from the kidneys through the ureters, thence carried to the bladder and voided at a fixed interval, is sufficient indication of their function." But how did they do this? Malpighi saw that the kidney consisted of a solid cortex opening into a hollow cavity, the pelvis. He saw the blood-vessels go into that solid part. He knew they must break up, and supposed the kidney was a kind of gland which extracted urinous elements from the blood. And he was right.

And then the human body, which is so commonplace, so much a matter of course, became for Marcello Malpighi a maze of fairyland. He saw that blood-vessels went into and blood-vessels came out of every organ — into the liver and kidneys and spleen — everywhere. And then,

of course, he knew they broke up into his little thin-walled capillaries, so the spirits carried in the blood could go into the flesh of those glands. And he wondered what each of them did there. And for the rest of his life he was like a madman in a frenzy. He investigated the liver and wrote a pamphlet about it. He investigated the spleen and wrote about it; some of its structures are still called Malpighian corpuscles. He investigated the skin and wrote a treatise about it; one layer of the skin is still called the rete Malpighii. He wandered like an insane ghost over half of Italy — from professorship to professorship. Thunderbolts of coarse abuse were launched at him by the pedantry of Pisa and Messina. He bore with calm fortitude his unpopularity with his patients and the active feudal wrangling of his relatives with a pompous and important family of dullards named the Sbaraglia. He immersed his arms in blood to the elbows, he cut sections and looked through glasses. His soul and body were in hell on this planet, but his mind was in collision with the stars.

2. *Generation*

Those were great days in the late seventeenth century when the boys were playing with their new toy, the microscope, improving it, making more powerful lenses, and thinking of new things to look at.

And then one day in 1674 Mr. Antonj Leeuwenhoek in Delft looked at something that nobody had ever thought of looking at before (characteristically, it was suggested by a student), and the world has never been the same since. Certainly it was one of the major events in history.

Many pious people think Mr. Antonj should not have pushed his anxiety for knowledge so far: such secrets, they say, belong to God. Others, such as the Society for Sexual Refawm, think it's just the greatest little topic in the world and want to reinvestigate it and discuss it all the time. Others, such as Baptist ministers and mothers with marriageable daughters, think the matter should not be mentioned at all — just thought about. Others, such as the Society for Birth Control, think Antonj did not go nearly far enough and, after having found the snake, should have discovered a way to scotch it. But nobody can deny that what Mr. Leeuwenhoek discovered was very, very interesting.

But before we get to that, we shall have to go back a little way.

One of the things that caused people to wonder, after it was recog-

nized that nature is a proper object for investigation, concerned the way animals grew before they were born. In the course of time, but by no means instinctively, it was recognized clearly that both a male and a female were necessary for the generation of a new individual. For mankind and the higher animals, the male element was known to be discharged into the female womb in the semen during the act of sexual intercourse. That was all very amusing, but what happened then?

Aristotle had some ideas, but we won't go back to Aristotle. Paracelsus tried it out in his practical way by putting some human semen "in a gourd glass sealed up, for the space of forty days, until it began to be alive, move and stir, which may easily be seen. After this it will be something like a man, yet transparent and without a body."

With our superior knowledge we know now that what happened to Paracelsus' semen was that it was invaded by germs, yeasts, and microscopic life generally. Only after these animals developed did it look as if it were alive. But according to Paracelsus' idea, he confirmed a very ancient doctrine that the generation of a new creature in the womb was a kind of putrefaction. The idea still persists in the office for the burial of the dead — "it is sown in corruption."

There came a time, however, when nature searchers wanted to know more about it. As Sir Kenelm Digby asked in 1644, "Are animals formed entirely at once or successively, one part after another, and in what order are the parts formed?"

The question had indeed been investigated by Harvey's old teacher at Padua, Fabricius. He had opened hens' eggs on different days during the process of their incubation. He drew pictures of the developing chick. He had opened the wombs of pregnant animals at different stages and recorded what he saw. All through the Middle Ages no one seems to have been curious enough to have thought of doing that. How excited Fabricius must have been when he looked for the first time, since antiquity, on those secrets of nature!

The idea that the ancients could not shake off was that the development of the embryo was simply a process of enlargement: the doctrine of preformation — that the new animal, from the very beginning, was preformed in the egg — perfect in all its parts, but infinitely minute. According to their lights, this was rational. They had no microscopes, and by the time the chick in the egg had developed to the place where it could be seen with the naked eye, it was actually formed in all its parts.

Still, as Fabricius showed, the parts were quite mis-shapen in their early stages and differed from their final form. There must be a process of change and moulding.

The influence of Fabricius on Harvey we saw in that Fabricius' discovery of the valves in the veins led Harvey to one of the best bits of experimental proof in the circulation theory. And even more is Fabricius' influence seen in Harvey's second book, on the generation of animals. *De Generatione animalium* was published in 1651, seven years after Kenelm Digby's inquiry quoted above.

Harvey actually watched and described day by day the development of the chick in the egg. The King gave him permission to kill pregnant does in the royal park and dissect the contents of their wombs. He refuted the old doctrines of corruption and preformation and showed the orderly development of animals before birth. His conclusion was: "*Ex ovo omnia*" — everything, men as well as birds, come from an egg.

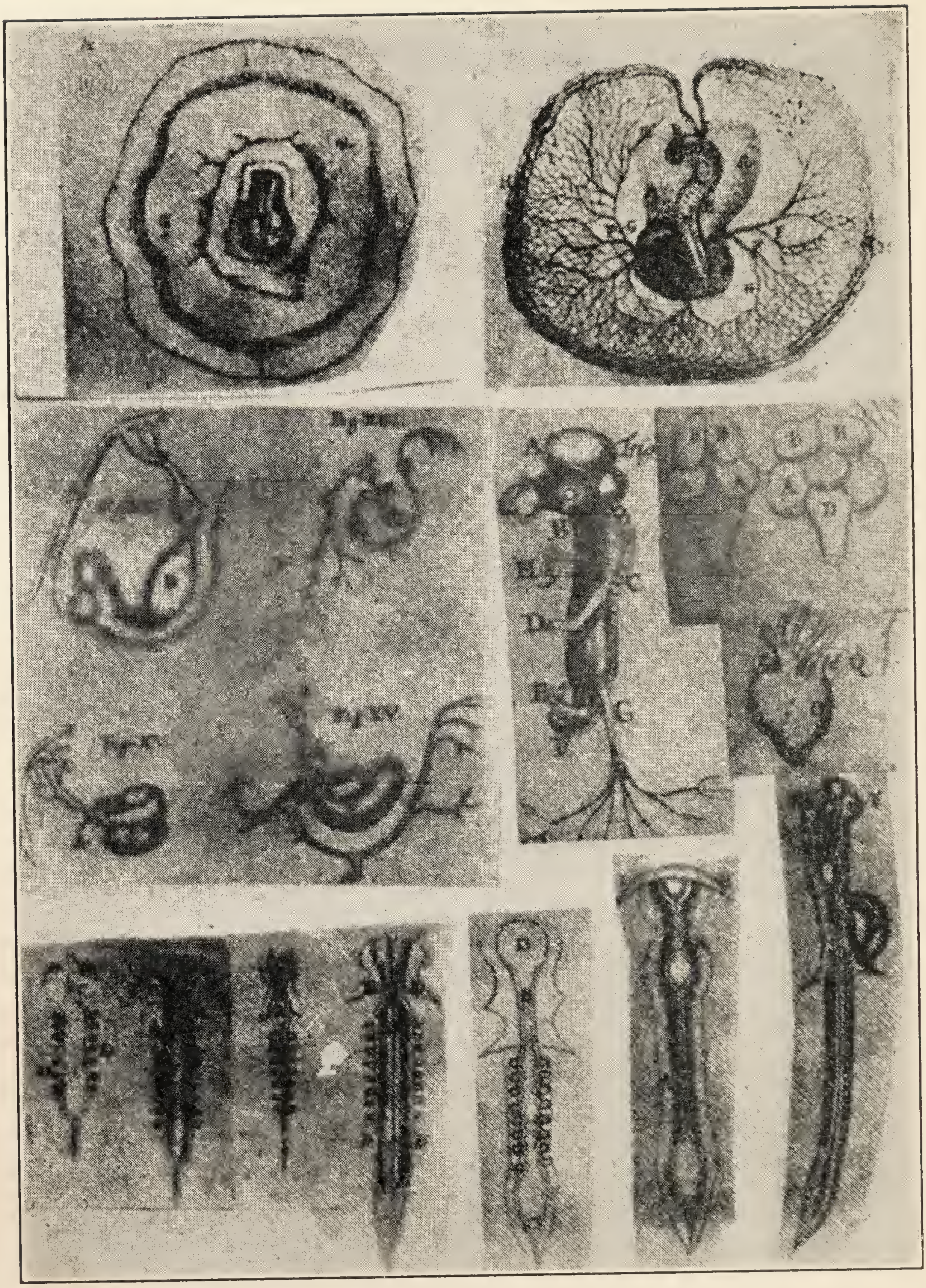
Fabricius and Harvey deserve to be called the founders of modern developmental anatomy — the science of embryology.

Then came the microscope, and that Italian, Malpighi, began to look at eggs with the microscope. He saw that the heart of the chick began as a little tube, that it coiled on itself and writhed into a heart and a set of blood-vessels. He saw that the brain and the spinal cord began as a groove in the back of the forming animal (still called the neural groove). He saw the eyes form as specks, and then as little blisters or globes. His work *De formatione pulli in ovo* was sent to the Royal Society in 1673.

It was a great advance, this idea that the body develops in an orderly manner, but even with all his accurate observations Malpighi still believed that the animal was really preformed before development began, and that the process was only a kind of visceral gymnastics. The microscopes were not powerful enough yet.

Now we are ready to hear of Mr. Antonj Leeuwenhoek's discovery. Let him tell it in his own words: "After I had demonstrated some of my observations with the microscope to a Mr. Ham, he brought me, in a small glass vial, the spontaneously discharged semen of a man who had lain with an unclean woman and was suffering from gonorrhœa, saying that he had seen living animalcules in it. He judged these animalcules to possess tails and not to remain alive above twenty-four hours. He also

Fabricius' study of the development of the chick.



Malpighi's sketches of the development of the chick. 1672.

reported that he noticed that the animalcules were dead after the patient had taken turpentine.

"I have divers times examined the same matter (human semen) from a healthy man (not from a sick man, nor spoiled by keeping for a long time, but immediately after ejaculation, before six beats of the pulse had intervened) and I have seen a great number of living creatures in it. These animalcules were smaller than the corpuscles which impart a red colour to the blood. Their bodies were rounded, but blunt in front, and running to a point behind, and furnished with a long tail, about five or six times as long as the body. They moved forward with a snake-like motion of the tail as eels do when swimming in water.

"What I here describe was not obtained by any sinful contrivance on my part, but the observations were made upon the excess with which nature provided me in my conjugal relations."

What Leeuwenhoek saw were spermatozoa, the active male element in generation. He afterwards found them in the semen of other male animals — horses, boars, dogs, etc.

This discovery caused a great stir, as well it might. Members of the Royal Society spent a great deal of time examining semen under the microscope. The moving tailed animalcules were shown to King Charles II — who certainly must be ranked as an expert on the subject. They were talked about everywhere.

Now here was a pretty quandary. The male semen or generative element could be examined readily. But what about the female element? There wasn't any of that to examine. The very essence of generation was that the female element stayed inside the female body. Then someone had a brilliant thought — what about the menstrual blood? That stayed inside the female as soon as pregnancy began. So the theory for a long time was that these lively little male animals entered the womb and moulded the retained female blood into a new individual. Just as an army of masons might mould a piece of sculpture.

This theory, however, was quickly followed by another — one of the most fantastic which ever engaged the attention of mankind: the theory of the homunculus — almost the old preformation doctrine. Coiled up in the head of the spermatozoan was in reality a microscopic little human being — every part complete. Generation is no more than the development of this little man (this homunculus) in the matrix of the womb. Just as a seed contains a microscopic plant which develops in

Homunculus in human spermatozoon. After Hartsoeker. This represents the doctrine of preformation, which supposed that the development of a new individual in the womb was simply a process of enlargement of a complete tiny individual in the germ-cell.

the earth. The sperm was the seed; the menstrual blood in the womb, the soil.

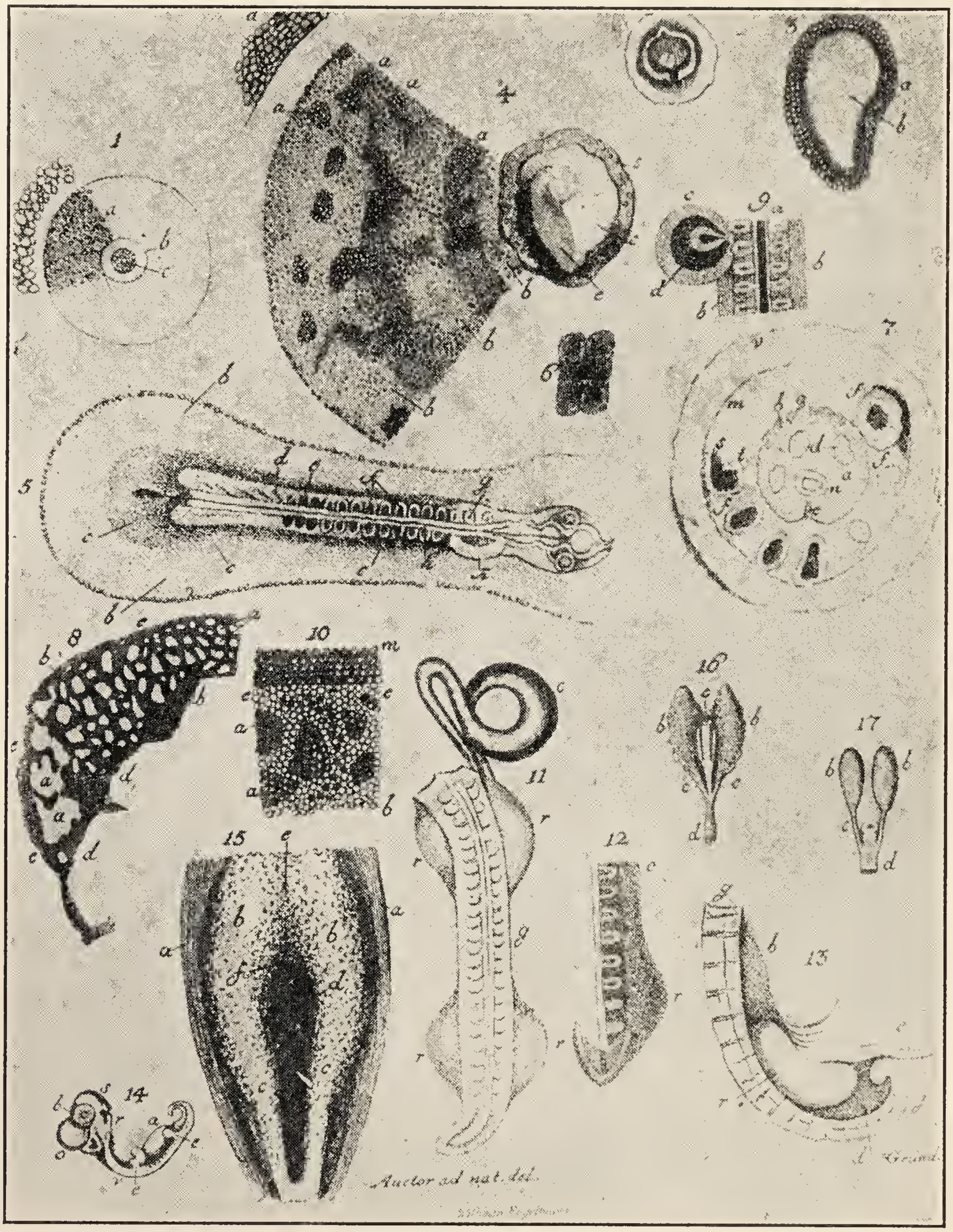
In 1694 Hartsoeker published a picture of a sperm with a homunculus in it which he claimed to have seen under the microscope.

The preformation doctrine at its worst. Figure of a fœtus seen in human male semen, as imagined by Gautier d'Agoty.

There was much wagging of tongues and building of theories about these things. But the homunculus theory held the floor for many years.

As late as 1750 Gautier d'Agoty published a weird nightmare figure of a preformed fœtus as it appeared in male semen.

In the course of the argument an even more startling theory was for



Wolff's figures of tissues developing from undifferentiated cells. 1759. His pictures are obscure and not easy to identify.

a time seriously advanced — that of emboîtement, or encasement. This held that not the male element but the female element contained the minute animal inside it. If so, it was pointed out, that little animal, if a

female, held another little animal inside its ovaries, and *that* little animal, etc. — like a nest of boxes. When the line was carried back to Eve, the supporters of the theory were not staggered. They declared that Eve had inside her body the minute replica of every human being who ever had been or ever would be on this planet. However vehemently the supporters declared their faith in this doctrine, their disciples balked and the idea fell of its own weight.

The modern theory of development of the new individual was first clearly stated by Caspar Friedrich Wolff, who, though a German, made most of his observations in Russia under the patronage of Catherine the Great. In 1759 he published his *Theory of Generation* and in 1768 observations on the development of the intestines of the chick.

In plants, Wolff showed, special structures, such as leaves, roots, flowers, spring from undifferentiated tissues. The growing plant begins as an area of such undifferentiated tissue. So in the animal, organs, such as the intestines, gradually develop from homogeneous tissue, which does not indicate in any way what its final structure is to be.

This idea of epigenesis ("origin upon") was opposed to preformation, and, since its brilliant defence by Meckel, has held its ground as the true explanation of the development of new living individuals.

Thus some solid achievement had been gained by the beginning of the eighteenth century. It was known that a living thing of some kind was necessary for the development of a new individual — spontaneous generation was discarded. And in the higher animals somehow, by what mechanism unknown, both male and female were necessary to the process. And that a series of different stages took place during the development.

Understanding of the exact mechanisms had to wait for more powerful microscopes — and for the genius of von Baer.

PART III

ADVANCES IN THE TREATMENT OF DISEASE

RESULTING FROM THE DEVELOPMENT OF THE FUNDAMENTAL SCIENCES

It was convenient in recounting the advance of the fundamental sciences to follow the progress of anatomy, physiology, histology, and embryology through a period of over two hundred years. We must go back now, because practice began to apply the new discoveries as soon as they were announced.

CHAPTER VIII

AMBROISE PARÉ AND THE FIRST MAJOR PROBLEM OF SURGERY

In the ancient city of Paris some time in the year 1580, during the reign of his most puissant and Catholic Majesty King Henry III, there lived, in the rue Saint-Denis, a grocer named Le Juge.

He was a jolly friendly fellow whose shop, at the sign of Le Gros Tournois, was justly popular and prosperous.

It was, of course, a period of troublous times. The question of a man's religious beliefs in those days was a matter of life and death. Many French people had embraced the new Huguenot faith and had cut themselves off from Mother Church. But the King and the court, whipped into line by the old Queen Mother, Catherine de' Medici, remained firm in the family religion. Thus it was not healthy for a man to air his views. The recollection of the terrible night of St. Bartholomew's eight years before was still fresh in everyone's mind.

The grocer, Le Juge, had acquired substance by carrying out a policy of keeping his ideas on religion to himself. He was far richer in this world's goods than anyone suspected, and he was looked up to as one of the solid and important citizens who made the backbone of that great, growing, hopeful city of Paris.

So when misfortune in the shape of an accident came to him, the family got the best medical advice they could summon. The misfortune occurred thus:

Le Juge was threading his way homeward in the darkened streets one night and stumbled. He fell upon his head, and a sharp stone cut him a gash in his temple.

When he arrived home, he was a deathly sight. Blood covered his pale

face and streamed over his clothes. The sight of him was so ghastly that one of his daughters fainted — which was a custom of the time supposed to show great sensitiveness — and his wife shrieked and threw her apron over her head and ran distractedly about the house like a ninny.

The poor fellow was so weak from loss of blood that he could not gather strength to reprove such silly female actions, but cast himself in a chair and himself immediately fainted dead away. And in this condition his servant, who had been roused by the cries of the agitated family, found him.

The servant brought his master some wine, which revived him, and, having been to the wars and having heard the opinions of the great Ambroise Paré, he washed the wound with wine and staunched the flow of blood with a towel. Under this treatment in a few minutes the grocer blinked his eyes and showed signs of returning consciousness.

"Stop your infernal and deafening screeching," he commanded his women with such force as he could summon, "and fetch me a barber to surgeon me."

"Whom shall we send for, master?" asked the servant.

"Send for Jean Cointeret, *chirurgien juré* (sworn surgeon of Paris)," answered the patient, weakly.

In a short time the great man arrived — in the long robe which every member of his craft wore and for which they were called "surgeons of the long robe."

He examined the patient. He felt the pulse. He clucked his tongue. Then he looked at the wound. Then he clucked his tongue again. The women stood around, frightened. Finally Cointeret said: "Well! What to do? There is nothing else to do, the wound wants cauterizing." And opening his gown, he got out his iron.

When he had heated the iron at the fire, he proceeded to sear the edges of the wound. The patient gripped the arms of his chair, and the sweat came to his forehead. But he did not cry out.

The physician praised him for his fortitude.

"You are a man of sense," he observed. "And your troubles are over."

It was true — the blood had ceased to ooze from the cut.

The surgeon was paid his fee and departed.

After a few minutes his family began to put the unfortunate grocer to bed, but no sooner had he stood to his feet than the blood began to well out from below the caked portions of seared flesh.

Here was cause for consternation indeed!

"Run after that accursed surgeon with his long robe," Le Juge ordered his servant. "No, see here — I am in no mood to be burned again. Rouse my neighbour, Paulain, and bring him and his servant in here. Give me a napkin to my face."

The neighbour, Paulain, when he arrived, shook his head gravely over the story and nodded sympathetically when he heard of the cautery.

"You are rich, Le Juge," he said, shaking his fat head. "You are rich and must always be getting the best. That is all very well for some things — but these surgeons — I do not know if it is best to get one of the best ones of them. They are so arrogant. And before you can wink, they are burning you or cutting you. See here, my friend, why not get the barber Viard — eh? We will send our servants together." (For it was hardly safe for one man to be alone in the streets of Paris at night in the old time.)

Le Juge was anxious for this, but thought they should also have Cointeret, the surgeon of the long robe, back. And so it was arranged.

Viard arrived first. As he was examining the wound, the dignified figure of the sworn surgeon entered the room. The humble barber-surgeon drew back to make way for his social superior. The great man greeted him with a mixture of arrogance and condescending affability and proceeded to look himself at the wound once more.

"Give me the iron again," he announced, with decision.

A groan of unutterable misery escaped the wretched patient.

"I cannot stand the iron again," he said pathetically.

"Tut, tut — " began the sworn surgeon, when he was interrupted by Viard.

"By your leave, sire — may I suggest, M. Cointeret? My father-in-law, the excellent Paré, whom you know and who speaks in terms of the greatest admiration of M. Cointeret — he is much interested in these cases. He was speaking to me the other day — "

But at the name of Paré the whole household began to chatter in excitement.

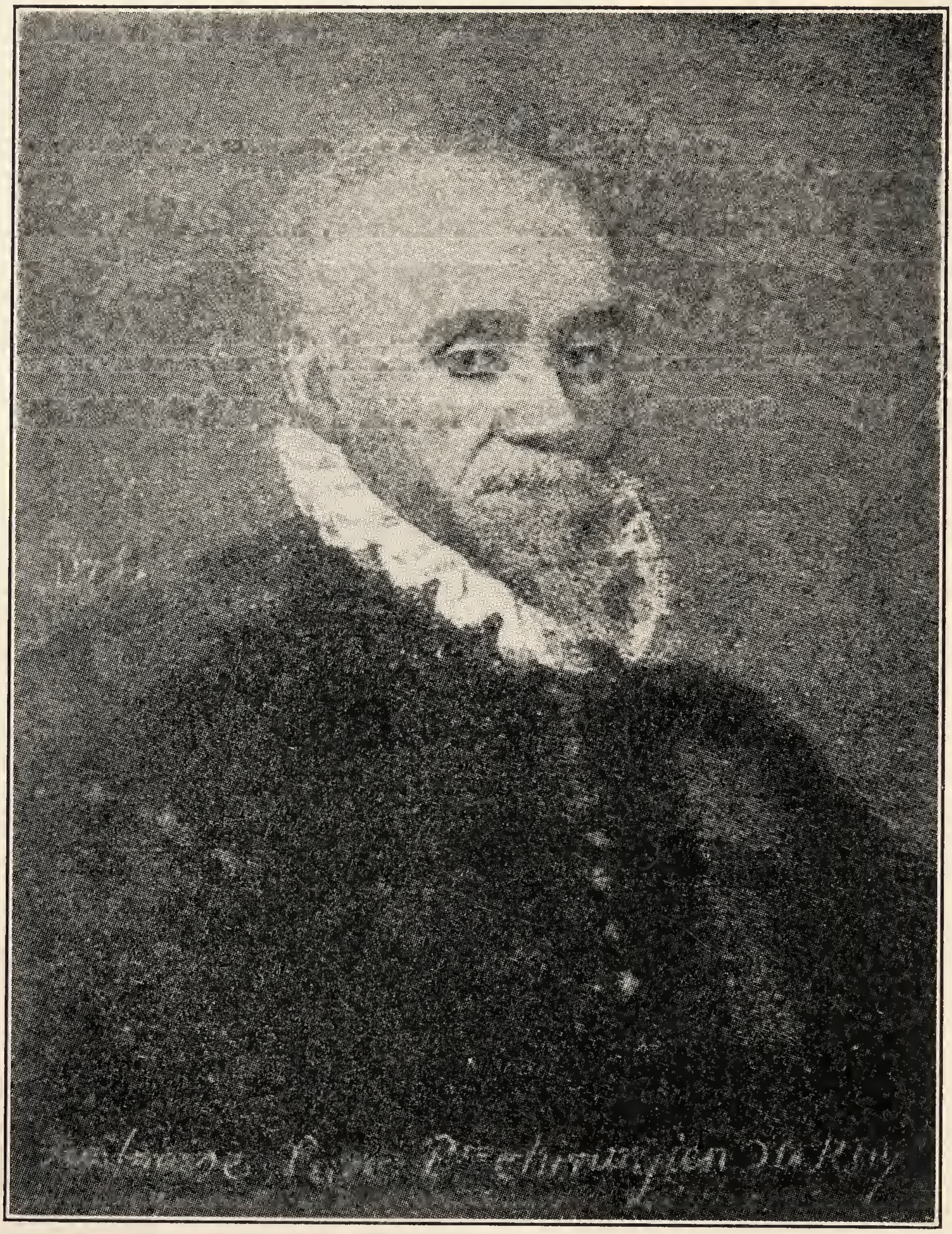
"Oh! Would the good docteur come to attend my husband?"

"Quick, quick, send for Paré!"

"Yes, if he would only consent — ah! the good docteur Paré — the King's physician."

Against such a storm Cointeret could do nothing. With what grace he could summon, he said:

"I am willing to have Ambroise Paré see this case. He is a *leetle* old,



Ambroise Paré. He taught the surgeons to control hæmorrhage by the use of the ligature instead of irons and boiling oil.

but then — it is proper with me. I have always been a friend to him. We were together when he opened the body of his late Majesty to ascertain the cause of death."[1]

[1] The late majesty was Charles IX, who ordered the Massacre of St. Bartholomew and who died in 1574.

When the servants had departed with a note from Viard which was designed to bring the old military surgeon to the patient, Paulain whispered to Cointeret:

"You really saw the inside of the body of the King?"

The surgeon nodded his head with portentous gravity.

"Now tell me, messire," the fat neighbour pressed him, "how does the inside of a king look?"

"Much as other men's," responded the surgeon. "This King's chest was very foul. He had a phthisical humour which turned into a morbidity. And he stank to heaven."

The fat Paulain looked grieved at this evidence of the mortality of kings, and he crossed himself piously.

"Have you cut open many other men?" he asked.

"Only for embalming them," the surgeon answered cautiously, for he had no desire to have any gossip come to the ears of Mother Church.

There was a bustle at the door, and a little old man came walking rapidly forward. His black beady eyes seemed to take in every detail of the scene.

"This is Master Ambroise Paré, the surgeon," said Viard to the grocer, and he proceeded to explain the circumstances to his father-in-law.

The very presence of the little man brought peace and confidence.

"Ah, Cointeret!" he said, observing his rival. "Up to your devils' tricks with these burning irons again, eh?" And his eyes danced with merriment. "Well, it is hard to get an idea into an educated man's head — you should fall on the street some time yourself, Cointeret, and cut a great gash in your skull — then we could pour some knowledge into you," he chuckled.

"See here, goodwife," he commanded, "get me a needle and a basting thread — mind it is a stout thread," he cried, as Madame Le Juge scuttled away.

"Now, see here," he said, when the household implements had arrived. And taking the threaded needle, he drove it deftly, with a single stroke, through the flesh below the cut on the grocer's temple. Then he took the two ends of the thread and, pulling them tight, tied them together.

The oozing of the blood stopped with an almost miraculous suddenness. The grocer asked for a clean towel and, applying it to his cheek, got only a small quantity of blood.

"See," said the little man, turning to Cointeret, "that is how I learned to treat wounds; not out of books."

The sworn surgeon of Paris shrugged, and said: "That will set up a humour of suppuration and never heal — poor man."

"Pish, tush," answered the little doctor. "You should trust more in the good God, Cointeret. He can heal a wound when even a surgeon of the long robe is absent."

Illustration from Paré's Surgery, *1582, showing his method of using the suture to control hæmorrhage. A suture much like this must have been used in the case of Le Juge, the grocer, here described.*

This sent Cointeret to the door, in high dudgeon, but as he was about to leave, he paused for a Parthian shot:

"You had best not leave until you are sure he will not start to bleed again." And the door slammed.

"Good Cointeret," observed Paré, making himself comfortable in a chair by the fire. "There is some sense in Cointeret: he spoke sense just then, so I will sit here with you awhile, by your leave, my friend."

"The irons are very painful," murmured the patient, weakly, trying to express his gratitude.

"Ah, these surgeons, my friend grocer — you have never been to the wars? Ah, no, I thought so. I have been to the wars, friend grocer," said the old gentleman, slapping his thigh proudly, "and what I have seen of these surgeons! Now do you go to sleep while I do the talking.

"Yes, these surgeons! They learn nothing. It was a long time ago, I can tell you, I discovered how foolish they were. In 1537 at Suze — there were many wounded and I was a young man, not even qualified then, but I had to work, too — there were so many wounded. Well, I had read John De Vigo's *Surgery,* in Book One, of 'Wounds in General,' and how wounds made by firearms are poisonous and need burning oil poured in them. But knowing this was to cause the patients great pain, I first inquired what the other surgeons were using for a dressing and found it was to put the boiling oil into the wounds with tents and setons. This also I did for a time, but then one day my oil ran short. What to do? I thought I would lose my commission. But I had made up a digestant of yolks of eggs, oil of roses, and turpentine. And I used this in place of the boiling oil on the next cases.

"You may be sure I was worried over those men who did not get the regulation treatment. In the night I could not sleep, fearing some fault in the not cauterizing, lest I should find those to whom I had not applied the oil dead from the poison of their wounds.

"I rose very early to visit them and, beyond my expectation, I found that they to whom I had applied my digestive had suffered but little pain, and their wounds were without inflammation or swelling, having rested fairly well that night. The others, to whom I had applied the burning oil, I found feverish, with great pain, and swelling around the edges of their wounds.

"So I resolved never to treat wounds again with burning oil or hot irons."

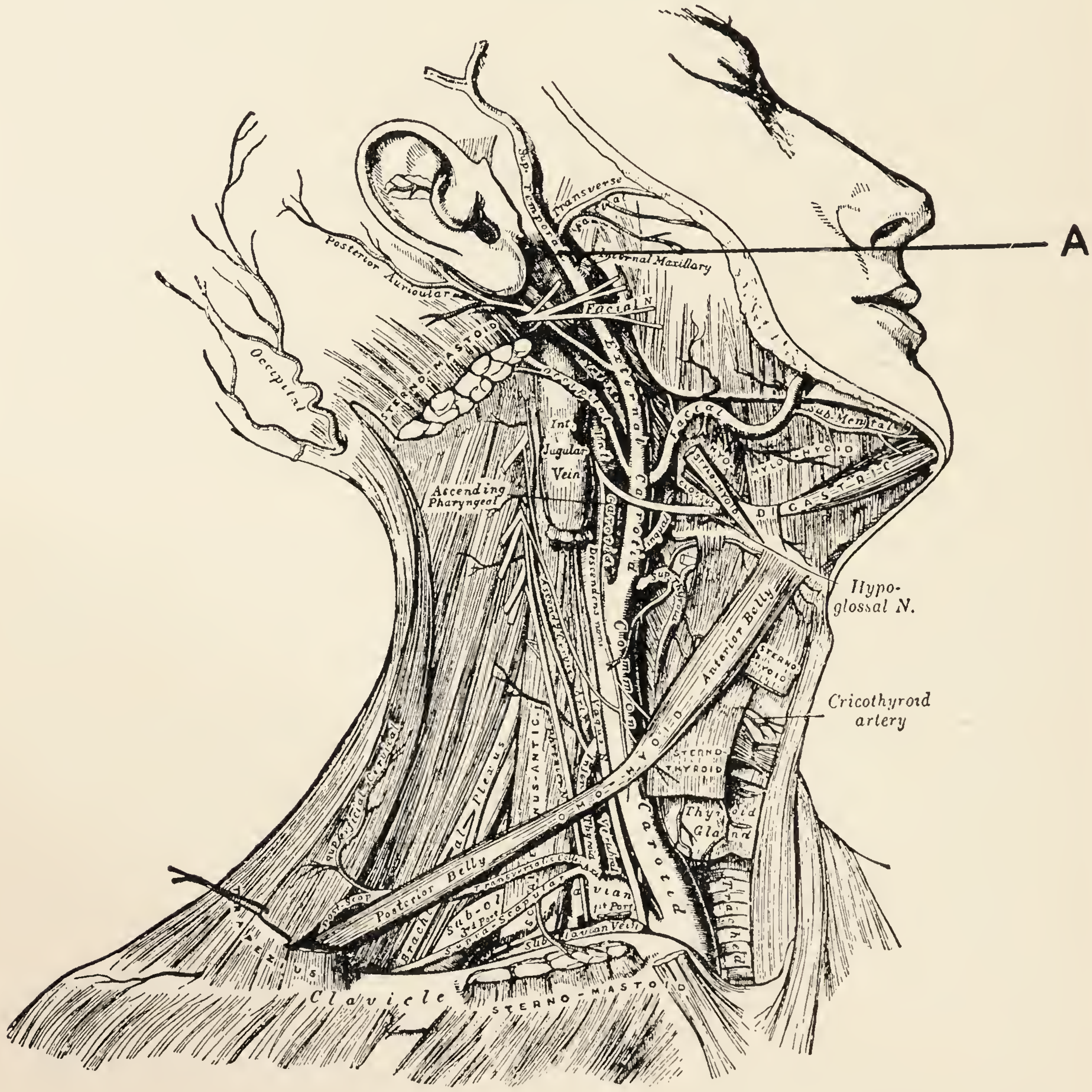
"Did you not heal M. le Marquis d'Auret, Master Paré?" asked the goodwife.

"I dressed him, and God healed him," answered the old surgeon, proudly — one of his favourite phrases. "The Duchess gave me a diamond for it, worth fifty crowns," he added, for there was a streak of vanity in him, too.

Soon the patient was nodding and Master Paré rose to go.

"Will you have a glass of wine?" asked the daughter, and jumped over a stool on her way to fetch it.

"Do you know what the girls of Vitry-le-François say, my dear?" laughed the old man. "That a maiden must not open her legs when she leaps or she will turn into a man. And I know how that saying started, for when I was on progress with our late King Charles, I talked to the Mayor of Bordeaux — what a devil was his name! — Mongaique



Anatomical drawing from Gray's Anatomy, *showing the arteries of the face. It was probably the artery just above and in front of the ear which caused the profuse bleeding in Le Juge's case. Paré probably put his stitch around the artery at about the point marked "A."*

— no, Montaigne, that was it. Michel de Montaigne, and he showed me a man named Marie. Yes, my children, a man named Marie. And he was thought to be a woman until he was fifteen years old, when one time, leaping and straining himself to overleap another, where before he was a woman, he suddenly felt the instrument of a man to come out

of him. And, by the good God's grace, when I saw this Marie, he had a long beard." And laughing and gesticulating, the old surgeon stamped out into the Paris dawn.

Thus my fancy paints Master Ambroise Paré, surgeon to His Majesty of France, as he lived in the flesh. Competent, utterly unspoiled by the learning of the schools, delighted to be called to see a sick man, shrewd, full of common sense, vain perhaps, a little old-fashioned, blunt, loving the old ways and the old days. A great man, messires et mesdames. The greatest surgeon, except Joseph Lister, who ever lived.

Surgery, it has been said, has three great fundamental problems: hæmostasis (the control of bleeding), anæsthesia (the control of pain), and asepsis (the control of infection). And Paré showed the most sensible and most painless way to control bleeding — by the ligature.

And this control of hæmorrhage is of far more importance than it may appear. For if your patient bleeds to death after you have cut into him to take away the diseased part, he is no better off than if he died of nature herself.

And, furthermore, if you are operating and your field is constantly flooded by blood so that you cannot see the structures you want to attack, the operation will not be much of a success.

Hippocrates had said that " diseases not curable by iron are curable by fire." So the old surgeons, knowing that a gaping wound could not be cured by iron (further cutting), interpreted Hippocrates as meaning that they should cure it by fire — the cautery.

Ambroise Paré broke with this and laid the foundations of rational surgery by treating hæmorrhage with the ligature.

The problem was troublesome until very lately. It did not confront the old masters in surgery much, because they were compelled by the limitations of their knowledge to do very simple operations. But when the discoveries of anæsthesia and asepsis came in, it was very pressing and its final solution fell to Dr. Spencer Wells, who died only in 1897. He invented a forceps — known as a hæmostat. The modern surgeon sets aside more hæmostats for his operation than any other single instrument. He could not get along without them. They are used to bite together the mouths of the blood-vessels laid open by the knife. Their

use seemed cruel to me when I was seeing my first operation, but they do no harm and are absolutely essential.

Of course, there were other surgeons before and about Paré's time. There were among the ancients somewhat legendary figures such as Soranus of Ephesus and Rufus of Ephesus, who is credited with having used the ligature himself. Then there were Guy de Chauliac (1300–70) and Henri de Mondeville (1260–1320), and Hieronymous Brunschwig (1450–1533), and John of Arderne (1306–90). But their stories are of little interest except to experts. You can read of them if you wish in Dr. Alfred Brown's book on *Old Masterpieces of Surgery.*

In the dim light of the past they hardly seem alive. But Master Ambroise Paré lives for us. A whole epoch comes to life in that delightful, gossipy, personal *Apology and Treatise* of his, which was published in 1585. He went everywhere and saw all kinds of people. For to the good physician the palace and the great house and the little cottage and the hovel are all opened wide; yes, and the hearts of their inhabitants. So Master Paré lets us see kings and beggars and honest merchants and soldiers, and he talks about them in no stilted, dignified, cramped, pedantic Latin, but in free, honest French. And he puts in all the little things one pines to hear. He admired his brother Jean, who was a surgeon at Vitré, because he was so canny in detecting the tricks of beggars. One woman used to stand at the church door on Sunday, pretending to have a cancer of the breast. She showed what seemed a loathsome sore. But Master Jean Paré noted that she was fat and well nourished, which did not go with the idea of a cancer, in his mind, so he pounced on her and disclosed a sponge under her armpit soaked in animal's blood and milk. Yes, in these pages we see the very vitals of the times.

If I had a son and he wanted to study medicine, he should begin on the *Apology and Treatise* of Ambroise Paré. Because there is something in that book he would find in none of his texts — there is life.

He was greatly loved by everyone except his rivals. The King had him locked up in a room in the palace on St. Bartholomew's Eve, so the story goes, because he was a Huguenot and possessed too valuable a life to be abroad in the bloody streets of Paris on that fatal night.

CHAPTER IX

EASIER AND SAFER MOTHERHOOD

On June 10 my grandfather used always to appear with a little white cockade in his hat. This was in memory of an event which took place a number of years ago and curiously, in a minor way, is connected with the advance of medical science in so far as it applies to the delivery of women in childbirth.

On June 10, 1688 the city of London was in a ferment of excitement, caused by a dozen circumstances, but all centred on the King. That King was James II, the brother of Charles II, who had founded the Royal Society of which Mr. Leeuwenhoek and Dr. Malpighi and Mr. Hooke were members.

James had succeeded his brother on the throne and had proceeded without more ado to get himself involved in a fine mess of difficulties. He was by faith a Roman Catholic, and his subjects were largely Protestant. He attempted by unconstitutional means to have his Catholic subjects admitted to all the privileges enjoyed by his Protestant subjects. He had ordered the bishops of the Protestant Church of England to read a declaration of indulgence to that effect. And this certain of them had refused to do. Seven of them, including the Archbishop of Canterbury, had been arrested and confined in the Tower.

The feeling of the people, which was antagonistic to the King, could possibly have been kept under restraint so long as the King and Queen had no son because then the succession would go to a Protestant branch.

But on June 9 it was whispered about the streets that the Queen was in labour and about to give birth to a child. She had been playing cards at Whitehall and, feeling the onset of labour, was conveyed in a sedan-chair across the park to St. James's Palace, where apartments had been prepared for her.

Comanche squaw in labour. A shelter of green boughs is provided for her outside the camp in order that she may have privacy during her delivery. Stakes are planted in the ground to furnish support for her during the pains in the early stages of labour. (After Engelmann. See bibliography)

Attendants were soon scurrying away to find doctors, midwives, and nurses — scurrying because the event was not expected for another month.

"Send for Dr. Hugh Chamberlen" was one of the significant orders.

And soon the large-framed, strong-handed man appeared at the palace.

How he was treated there by the other medical men is not recorded. Probably not very politely, because he was a much talked-about person who was in possession of a "secret" the others did not have. This secret was a means of extracting a living child from a woman in difficult labour.

Difficult labour is due either to an unnaturally narrow pelvic outlet (a deformed pelvic bone of the mother) or to an unnatural position of the child. The birth of a child, the process of labour, consists in the propulsion, by the muscular tissue of the womb, of the child through the opening in the mother's pelvic bone and through the tissues of the birth canal until it is outside the body of the mother. Normally, the size of an adult female pelvis permits this. Normally, too, the child's head comes first, and this makes, mechanically, for the easiest labour.

When the child is turned sidewise, delivery is impossible. Among primitive people such a condition is almost inevitably doom for the mother. Although the midwives of primitive tribes try desperately to turn the child by suspending the mother by her arms and kneading the abdomen, these methods are seldom successful and the poor woman dies in the most terrible agony.

Only two advances were made in the science of obstetrics from the days of Egypt until the seventeenth century. One was designed to facilitate labour when the child was in a sidewise or other difficult position. It was called podalic version. "Version" means "turning," and "podalic" means "by the feet." The manœuvre consists in putting the hand in the womb and catching the child by the feet when it is in a transverse or difficult presentation: the feet are drawn down out of the mouth of the womb, and in this position delivery is possible.

The other advance was the employment of instruments when the child's head presented, but was too large, or the mother's pelvis was too small, for it to pass through. The instruments, cranioclasts, were used to kill the child by breaking open its skull, extracting its contents, and forcing the bones together so that its body could be extracted.

Cæsarean section in the old days was employed after the mother was dead — killed by the shock of a difficult labour: the womb was cut open and the child extracted, when it could often be revived. In the early annals occasional cases are recorded of Cæsarean section being performed successfully on a living woman, although the dangers of infection in those days before a knowledge of asepsis were considerable. Now, of course, Cæsarean section is frequently performed on living mothers with the extraction of a living child.

Except for podalic version (which is still employed), these methods were obviously desperate. Killing the child by opening the skull with cranioclasts is a horrible and sickening procedure. And Hugh Chamberlen claimed to have a secret way, taught him by his father, for delivering the child alive in just such cases as the cranioclast would be employed in. No wonder he was in demand on such occasions.

What he did at the birth of King James's son we do not exactly know. On the morning of June 10, " a day," says Macaulay, " long kept sacred by the too faithful adherents of a bad cause " (so much for my grandfather), a boy was born, " the most unfortunate of princes destined to seventy-seven years of exile and wandering, of vain projects, of honours more galling than insults, and of hopes such as make the heart sick." In other words, the Old Pretender. His birth probably precipitated the overthrow of his father's reign and his family's exile. But he has served his purpose in introducing us to Hugh Chamberlen and he may pass out of our narrative.

And so for a few moments may Hugh Chamberlen himself. We cannot quite intelligently understand his contribution until we have followed something of the practice of obstetrics during the centuries. So we will leave him in front of St. James's Palace taking a lungful of spring air after his night's work, pausing for a moment to enjoy the loveliness of the Green Park before he claps his hat on his head and stalks off towards Charing Cross.

It is perfectly natural to suppose that every primitive people had, of necessity, to acquire some knowledge of the process of childbirth.

The essential facts to know are these: After a woman is impregnated, the child grows inside her body for a period of nine months. At the end of that period the process of labour begins, initiated by a set of pains, and

Childbirth in Ceram — an island north of Australia. The mother is tied to a tree with the hands above the head, almost suspended. She is attended only by the midwife. (After Engelmann. See bibliography)

the child is extruded into the outer world. The safest and easiest way for the child to be born is head first. The child is attached by means of a cord (the umbilical cord) to a large flat piece of flesh, the placenta, or afterbirth, and after the actual birth of the child the expulsion from the mother of this placenta must occur. The umbilical cord must be severed. In a few days the mother's breasts begin to discharge milk, and this is the best food for the child for several months, after which weaning may gradually be accomplished by the substitution of certain simple foods at first, and then gradually more elaborate foods.

All this primitive man knew. The signs of pregnancy — even early pregnancy — were known. The duration of pregnancy was calculated. In old Calabar, for instance, as with us moderns, the time of birth is predicted from the suspension of the menses. With North American Indians the mother is carefully looked after during this time, and in Japan the abdomen is regularly kneaded to correct any malposition of the child.

The Palintes recognize the approach of the onset of labour. Their ideas are based upon the fanciful supposition that the child remains inside the mother voluntarily and they starve it out as they would force a woodchuck out of its hole. So for days before labour begins, the mother is starved.

Most savages prepare a special retreat for the mother as the time of delivery approaches. The primitive mother, alone or accompanied by a female relative, usually seeks privacy when her term arrives. She finds a retired spot. "Upon the banks of a stream is the favourite place the world over, the vicinity of water, moving water if possible, is sought so the young mother can bathe herself and her child, be cleansed and purified when all is over."

Savage mothers, in general, have an easy time in labour. North American Indian mothers seldom suffer more than an hour. Dr. Choquette relates that a body of Indians, men, women, and children, set out on a hunting trip. "On a severely cold winter's day, one of the women, allowing the party to proceed, dismounted from her horse, spread an old buffalo robe upon the snow, and gave birth to the child, which was immediately followed by the placenta. Having attended to everything as well as the circumstances permitted, she wrapped up the young one in a blanket, mounted her horse, and overtook the party before they had noted her absence."

Assistance in the expulsion of the placenta is universally practised. The most frequent method is by an abdominal belt or binder. Dr. D. D. Taylor, surgeon, U. S. Army, delivered a Sioux squaw. "The moment I cut the cord she jumped to her feet, and, standing erect, seized the squaw belt, a leather belt about four inches wide, which she buckled over her hips and abdomen, drawing it as tightly as her strength would permit. Within a minute the placenta dropped on the floor."

The Kanikars in southern India apply the child to the breast at once. In the Transvaal, on the contrary, a soft mush is fed the child the first three days, and only after the real milk comes in is the child suckled.

Evolution of the obstetric chair.

The period of suckling varies greatly. The inhabitants of Sierra Leone keep the baby at the breast until it can walk. The Alaskans from ten to thirty months. In southern Arabia, to wean the child, disagreeable-tasting messes such as myrrh and asafœtida are smeared upon the mother's nipples, and in Zanzibar Cayenne pepper and the gum of the aloe are applied for the same purpose.

The posture of the mother during labour among uncivilized people is usually erect or kneeling. It is really a much more effective one than lying down. A curious and interesting development of it is the obstetrical chair. This, of course, came late in any civilization. Examples of this article of furniture can still be found in old farm-houses in

Virginia, Tennessee, Kentucky, and Missouri. It is an arm-chair with the seat cut out in a semicircular manner, so that the child can be extracted through this opening. According to Engelmann, its origin or model was the position of the husband, who often held his wife on his lap during her labour. It was obviously known to the Egyptians, as one of their hieroglyphic signs for the term " to give birth " is the picture of an obstetrical chair.

While primitive mothers have an easy time in labour if conditions are relatively normal, when things go wrong with them they go very wrong, and pathological labour among savages in almost all cases means death to both mother and child. In all uncivilized tribes methods of helping the mother in these circumstances are practised.

The commonest cause of trouble among primitive mothers, or at least the one for which means of help are most often devised, is delayed labour, owing either to lack of strength or to the wrong position of the child in the womb.

" The great danger in labor, and to the savage woman *the one* great danger, is a transverse position of the child. This they must use every means to avoid, as with them death is certain if labor is inaugurated with the child in such a position." (Engelmann: *Labor among Primitive Peoples.*)

The treatment practised by primitive people for both lack of strength of the womb and transverse position is usually to suspend the woman by the wrists and, clasping her abdomen, to push downward on the mass inside.

Along with rational mechanical means, the medicine man practises incantations to drive away the demons who are preventing the arrival of the new-comer. Inside her private hut or tent or corral, as the case may be, the poor creature is attended by a few female relatives and perhaps the husband, all trying to force the processes of nature, while outside, the ritual fires leap up, the tomtoms pulse monotonously in the night, and the screech and drone of the priest mingle with the cries of the distressed sufferer. It is a familiar scene, described by hundreds of travellers.

Even in Europe little progress was made in obstetrical science until quite late in the historical period.

All deliveries were in the hands of the midwife. The lore of the mid-

wife included, besides the things we have mentioned above, the sale of secret remedies to induce abortion.

Her activities at an actual delivery were probably confined to a report on the progress of events, to cutting the cord and delivery of the placenta, to washing the baby and mother, and to offering advice upon the arrival of the milk, and other counsels of sagacity. She knew the natural history of the process of labour — she knew its stages; she knew that in the first stage the woman had best be up on her feet walking around; she knew the signs which meant that the woman had best go to bed; she knew when the head was about to be delivered, and most midwives recognized when they were in trouble and needed help. Since she had no, or limited, knowledge of anatomy, there was little she could do to help a woman when either the child was in a bad position or the birth canal was deformed. Her great virtue was that she was not meddlesome. She did not thrust curious fingers into her patient's vagina, and therefore she had few infections. Indeed, the late survival of the midwife into our own time is due to the entirely different practices of male physicians.

But during the whole period of the dominance of the midwife over the rites of accouchement, obstetrics, as a science, made little more progress than is comprehended in being a shrewd assistant to nature. The accouchement of the Queen of France in 1601 by Louise de la Bourgeois was conducted with no more skill than the accouchement of the wife of an Egyptian dynast in 1800 B.C.

The early printed books on obstetrics were merely manuals for midwives. The most famous is the *Rosengarten* of Eucharius Roesslen, printed in 1513. This was translated into English with the title *The Byrth of Mankynde*. Similar books appeared in all European countries. They were much the same, copied largely from one another, and gave general directions for the conduct of pregnancy and labour, a table to determine the date of the expected birth, and sometimes some advice about complications and difficult labours. While designed for midwives, male physicians could read them, and after the renaissance of anatomy, a general interest in this department of medical practice grew.

Paré's treatise on obstetrics, published in 1550, incorporated in his book *A Short Compendium of Anatomy,* etc., brought to general attention an effective method of assisting in one form of difficult labours —

namely, by turning the child around in the womb, or podalic version. Hippocrates had also practised it, but the method had been forgotten. Paré's reintroduction of it constituted an enormous advance.

In order to make these studies, Paré was compelled to attend women in the lowest orders of society, prostitutes and impoverished wretches generally. No respectable woman, no wife of a good citizen of Paris, would think of admitting a man to her bedchamber during the delivery of her child.

The presence of Hugh Chamberlen and other male physicians at the lying-in of a queen, at the birth of a prince of the English royal family, represented, therefore, a considerable change. Just how great that change was can best be realized by the first-hand account of the delivery of another queen by a midwife some eighty years earlier.

Some time during the end of August 1601 a heavy coach bearing emblazoned on its panels the royal arms of France might have been seen lumbering along the sunlit, silent road from Paris to Fontainebleau.

There were outriders in profusion. The coachman had been told to drive carefully and slowly. Indeed, the journey took three days in that still, hot period before the autumn rains, while the dust settled on the leaves of the great trees through which the highway passed.

Inside the coach was an ample Italian woman with a sharp nose and curiously light colouring for one of her race. She was Marie de' Medici, Queen of France, wife of Henry of Navarre, whose white plume led the hosts at Ivry, daughter of that powerful Florentine house the Princes Medici. The fact that her figure can be described as ample is quite understandable, since she was in her first pregnancy, almost at term, and travelling to the palace at Fontainebleau for her first delivery. The care with which the coachman drove was also ordered by Her Majesty's condition.

With Her Majesty were her maid and a lady-in-waiting, and the King's fool (Master Gillaume) and possibly the court physician (de Laurens), to whom, I regret to have to announce for the honour of my profession, nobody paid very much attention. For the next most important member of the party after the expectant mother herself, was a reliable-looking woman, aged thirty-six years, tucked in the boot of the coach, to whose narrative powers we owe the details of this account.

She was Louise Bourgeois, *sage femme jurée,* or, in other words, licensed midwife, of the city of Paris.

It was Madame Bourgeois who was to accouch the Queen. The court physicians were brought along only for the possibility of an emergency.

The companions on this ride were not acquaintances of long standing. Marie de' Medici was the second wife of Henry IV. His first was Mar-

Louise Bourgeois. Portrait on the title-page of her Observations.

garet of Valois, who bore him no children, no heirs to the throne of France, no princesses to bargain in marriage with other powers.

But, as was the custom of the time, although I see no reason why historians should insist on that time as being particularly notable in this respect, the King had had several mistresses.

The one to whom his most romantic devotion was pledged was Gabrielle d'Estrées. If you wish to see her in all her regal beauty, go

down to the pleasant city of Tours on the banks of the River Loire and drive out some blossom-filled spring morning to the Château of Azay-le-Rideau. There, in one of the rooms, is a portrait of Gabrielle, painted by command of her royal master, while she was at the height of her power and prestige. She is at her toilet, naked to the waist, and behind her the little Duc de Vendôme, her son, mischievously steals some fruit. The appointments of the room, the attendants — a wet nurse and an admiring chambermaid — gaze admiringly and serve to set off the beauty of her torso. The painter was evidently under orders to render the soft brown duskiness of the unblemished skin with inspired faithfulness. The face is dark, impervious — Provençal.

Such was the mother of most of Henry of Navarre's children before his second marriage of state to the daughter of the Medici. One of them, the little Duc de Vendôme, who appears in the portrait mentioned above, will be heard of in our story. Henry's life with Gabrielle d'Estrées seems to have been an ideally happy one. They were devoted to each other and to their children. Some contemporary gossip describes their last meeting, after the King had been forced to arrange for his union with the Medici — how they rode long through the sun-drenched forest of Fontainebleau one summer day, and finally the King's horse was turned one way and Gabrielle's another, and, after a sudden, passionate embrace, they rode wildly away from each other, the tears coursing down the cheeks of the great-hearted Henry.

Gabrielle died before the installation of the King's second wife. Poisoning was suspected, as it so often was with the great of those days, but it is almost certain that she died of puerperal convulsions — that is, of a natural disease of the state of pregnancy.

Most of Gabrielle's accouchements were attended by a certain Madame Dupuis, a licensed midwife of Paris. When the new Queen of France, Marie de' Medici, became pregnant almost immediately after her marriage, the King suggested that Madame Dupuis be officially engaged. This was a natural thought on his part, perhaps, but tactless. The daughter of the Medici was not one to accept the services of the midwife who had attended her husband's mistress. She therefore made inquiries for other practitioners. Her inquiries resulted in bringing to her attention Louise Bourgeois.

The history of Louise which the Queen obtained was that she had been born in 1563 in the faubourg Saint-Germaine, not far from the

home of Ambroise Paré. Among Paré's pupils one who lived in Paré's house during the early womanhood of Louise Bourgeois was a barber-surgeon named Martin Boursier, whom she married. Her interest in

Gabrielle d'Estrées and her children. From the portrait at Chantilly. The little Duc de Vendôme, who is mentioned in Louise Bourgeois's narrative, is seen peeping round his mother's arm.

the practice of obstetrics began when she went through the process of motherhood herself. Shortly afterwards she began to practise the art as an unlicensed midwife. She was instructed by the illustrious Paré himself and also by her husband and became, it is said, very proficient,

being naturally dextrous and intelligent. With the powerful influence of Paré she quickly built up a large and remunerative clientele.

With the introduction of Paré's method of podalic version and the discovery and dissemination of accurate knowledge of the anatomy of the female reproductive organs which followed the work of Vesalius and his fellows, the status of the male obstetrician changed. There was in Paris at the time of Marie de' Medici's accouchement a widely known man obstetrician named Guillemeau. He had been a pupil of Paré's and had modified Paré's method of podalic version so that he brought the baby's leg down to act as a plug in case of hæmorrhage from the placenta prævia.[1] Guillemeau was suggested to Marie de' Medici as a substitute for Madame Dupuis, but the conservative view of an Italian Princess towards male obstetricians was expressed in her constant reference to him, not by name, but as *"cet homme de Paris qui accouche des femmes."* The time was not come when a queen of France would admit a man to preside at her accouchement.

The next candidate was Louise Bourgeois. She was selected by the Queen's own physician, de Laurens, and the meeting between the two occurred at the Hôtel de Gondy.

It took Her Majesty "but the space of a pater noster" to decide in favour of the reliable qualities of the new midwife, and she was forthwith engaged.

The Queen and her companions spent, as we have said, three days on the journey between Paris and Fontainebleau. And after they arrived, it was many days before any signs of the expected event were manifest.

Then:

"La nuict du vingt-septiesme Septembre à minuict, le Roy m'enuoia appeller, pour avoir la Reyne qui se trouvoit mal," begins the *Récit véritable de la naissance de Messeigneurs et Dames les Enfans de France* — Louise Bourgeois's famous book. We will let her tell it in her own words:

"On the night of September 27, at midnight, the King sent to have me called to come to the Queen, who felt ill. I was in bed in the boudoir

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[1] Placenta prævia is the condition in which the placenta (the set of blood-vessels which attaches to the inside of the womb and by means of the umbilical cord conveys pure blood and nourishment to the child) is misplaced so that it comes over the mouth of the womb and by its premature detachment begins to bleed. The amount of blood lost in this way may be fatal.

with the chambermaids; often for fun they had given me false alarms. They found me asleep, and, this having happened so often, I thought it was the same thing. But I heard myself being called by Pierrot. He did not give me time to dress, he hurried me so!

" As I entered the Queen's room, the King asked: ' Isn't that the midwife? ' They told him it was. He said: ' Come, come, midwife. My wife is ill. Find out if she is about to be delivered; she has terrible pains.' I investigated and assured him that such was the case. Instantly the King said to the Queen: ' My love, you know I have told you several times that the princes of the blood must be present at your delivery. I beg you to consent; it is because of your high rank and that of your son.' To which the Queen replied that she had always been determined to do everything to please him. ' I know, my dear, that you want to do as I wish, but knowing your nature, which is timid and modest, I fear that unless you use great resolution, seeing them will prevent your delivery, and so again I beg you not to be shocked, since it is a custom at the first delivery of queens.'

" The pains gripped the Queen, at each of which the King held her and asked me if the time had come to call the princes, that I must warn him, as the matter was of great importance that they be there. I told him I would not fail if there was time.

" About an hour after midnight the King, overcome by impatience at seeing the Queen suffer, and thinking she would give birth before the princes had time to get there, sent for them. They were the Princes de Conti, de Soissons, and de Montepensier. The King said, waiting for them: ' If never one has seen three princes very full of pity and good nature, who, seeing my wife in labour, would give most of their possessions to be far away from here, he will see them now! My cousin, the Prince de Conti, will not easily understand what anyone says, seeing my wife tormented; he will believe it is the midwife who is doing it. My cousin, the kind de Soissons, seeing my wife's agony, will have deep solicitude at finding himself compelled to stay; and as for my cousin de Montepensier, I fear he will fall down in his weakness, for he is not able to see anyone suffer.' All three came before the two hours and were there about half an hour. The King, having learned from me that delivery was not very near, told them to hold themselves in readiness until he called.

" In the meanwhile the great bedroom of Fontainebleau, which is

near the King's bedroom, was prepared for the confinement of the Queen. In it there was a great bed of crimson red velvet, ornamented with gold, near the bed of accouchement. There were also two pavillons,

The official representation of the birth of Louis XIII from a painting by Rubens, Musée National du Louvre, Paris. The actual facts will be found in the narrative of Louise Bourgeois in the text.

large and small, attached to the floor. The large pavillon was stretched and fastened like a tent by its four corners with cords; it was of beautiful Holland linen, about twenty ells square. In the middle of the large

tent there was a little one of the same linen, and under this was put the bed of accouchement. Here the Queen was put to bed on coming out of her bedchamber.

"The ladies whom the King had desired especially called to the accouchement of the Queen were summoned. There was carried under the pavillon a chair, some folding seats, and some stools for the King, Madame his sister, and Madame de Nemours, to sit on.

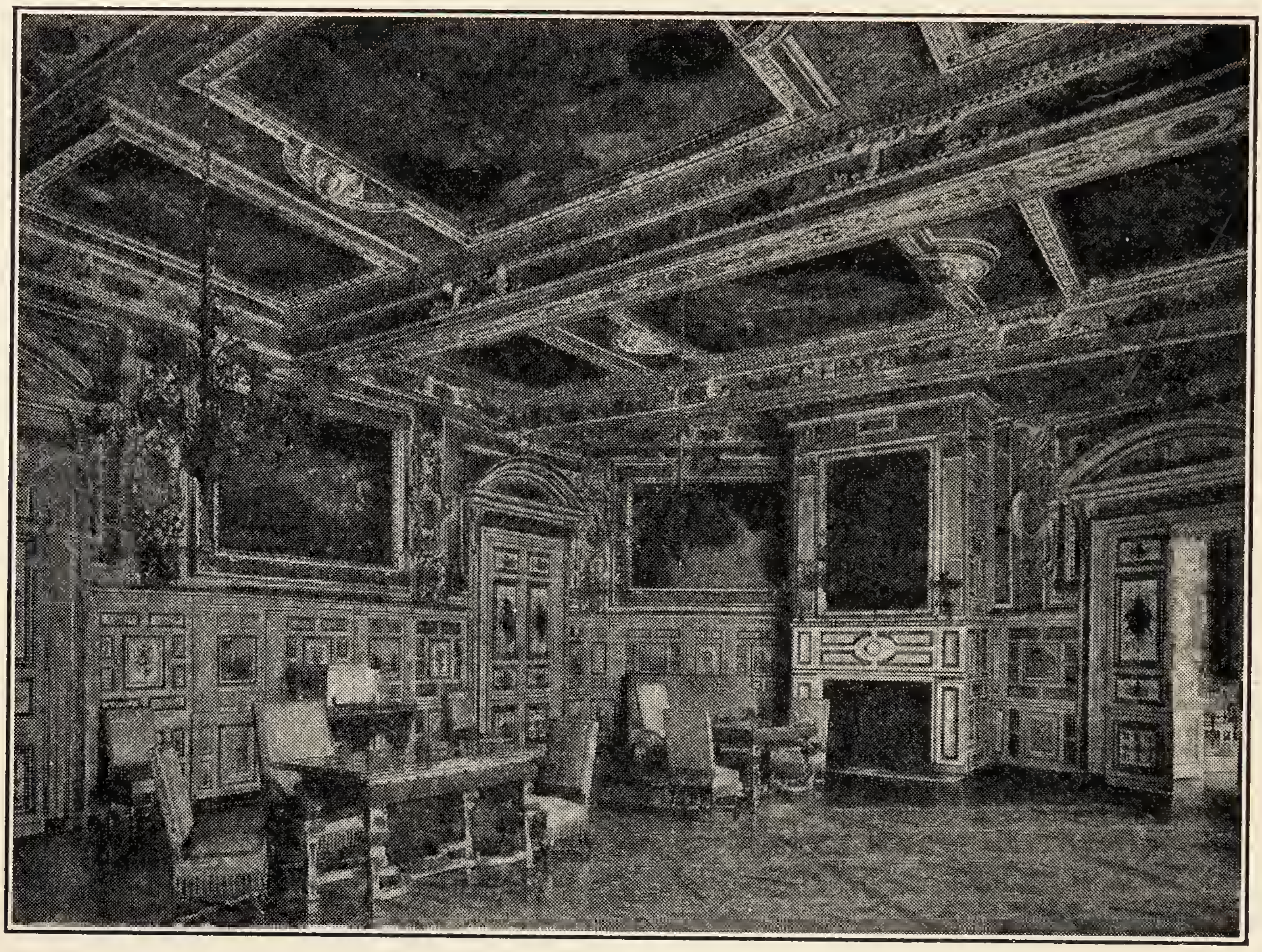
"The obstetrical chair was also brought in; it was covered with crimson velvet. About four o'clock in the morning a great colic, mingling itself amongst the travail of the Queen, gave her terrible pain without helping her along. From time to time the King made one of the doctors come to see the Queen and speak to me so that I might know what was taking place. The colic made the Queen suffer more than the travail, and even kept her from it. The doctors asked me: 'If this were a woman and you were alone with the case, what would you do?' I proposed to them some remedies, which they ordered at once from the apothecary, who proposed to them others in the Italian style, which he said in similar cases had done much good. Knowing the great zeal which the apothecary had in the service of Her Majesty, and knowing that if the remedy did not do all the good he claimed for it, it could not do her any harm, I made no protest, so they gave it to her.

"There were also two old and wise Italian maiden ladies with the Queen, who had assisted at the birth of many children and had attended many accouchements in their own country. The Queen, to show her friendship for them, had wanted them at her confinement to serve as ladies' maids. The relics of Madame Sainte Marguerite were on the table in the bedroom, and two holy men from Saint-Germain-des-Prez prayed God without ceasing.

"The Queen's sickness lasted twenty-two and a quarter hours, and her courage was an admirable thing. She discerned clearly the first pains as well as those last ones when the terrible colic came. During all the time she was in travail the King never left her once, excepting when he went out for something to eat; then he sent constantly for news from her, and madame his sister did the same.

"The Queen before her confinement did not wish that the little Monsieur de Vendosme should come into her room during her illness, because of his youth, but she, on account of the pain, did not take note of his presence. He asked me every little while 'if the Queen would soon

give birth.' To quiet him, I said: 'Yes.' Then he asked me what the child would be, and I told him it would be what I wished it to be. 'What,' said he, 'is it not yet made?' I said: 'Yes,' that it was a child, but that I could make it a boy or a girl, whichever pleased me. He said to me: 'Midwife, since it depends on you, put the pieces of a boy into it.' I said: 'If I make a boy, monsieur, what will you give me?' 'I will



Fontainebleau. The birth chamber of Louis XIII as it now appears.

give you everything you wish, or, rather, everything that I have.' I said: 'I will make it a boy and will not ask anything of you but the honour of your kindness and that you will always wish me well.' He promised me that, and kept his promise.

"When the remedies had driven away the colic and the Queen's real labour commenced, I saw that she restrained her cries. I begged of her not to suppress them, for fear her throat would swell. The King said to her: 'My dear, do what your midwife tells you — cry, that your throat may not swell.' She desired to be confined in her chair, and, being seated, the princes who were beneath the large pavillon sat face to face with her. I was on a little seat before the Queen. I placed Monsieur le Dauphin in his linen wrappings, so that no one knew, except-

ing myself, what sex the child was. I wrapped him up well — this I understood was what I had to do. The King came near to me. I looked closely at the face of the child and saw he looked very feeble because of the great pain which he had endured. I asked for some wine from M. de Lozeray, one of the first valets de chambre of the King. He brought a bottle — I asked him for a teaspoon — the King took the bottle, which he held. I said to him: 'Sire, if it was any other child, I would put the wine in my mouth and give it to him that way, because of his feebleness.' The King put the bottle against my mouth and said: 'Do it as you would to another.' I filled my mouth with the wine and thus gave it to the child. At that instant he was conscious and tasted the wine which I had given him.

"I saw the King sad and changed — he had drawn away from me. He did not know what sex the child was — he had only seen its face. He went to one side of the pavillon and told the two femmes de chambre to get the bed ready. I nodded at Mlle de la Renouillière to give her the signal so that she could go and get the King out of his trouble; she was fixing the big bed. Then I saw Gratienne; I said to her: 'My girl, warm a piece of linen for him.' Then I saw her go over to the King, who pushed her aside and would not believe what I had just told her. He said that it was a girl — that he knew it by my face. She assured him that it was indeed a boy and that I had told her so. He said to her: 'She made a wry face.' 'Sire, she told you that she would make it,' and he said to her: 'That is true, but it is not possible if it had been a boy she could have made such a face.' She replied to him: 'It is possible, because she did it.' Mlle de la Renouillière came in. She saw the King was angry with Gratienne. She came to me and I gave her the signal. She questioned me in my ear and I whispered back: 'Yes.' She took off her cap and went to make reverence to the King. She told him I had given her the signal and had also told her in her ear that it was a boy. The colour came back to the King. He came over to me beside the Queen and bent down to put his mouth against my ear and asked me: 'Midwife, is it a boy?' I said: 'Yes.' He said: 'I beg of you, do not give me a short joy — that would kill me.' I unwrapped the little Monsieur le Dauphin and let him see that it was a boy, but so that the Queen did not see anything. He raised his eyes to heaven, joining his hands, and gave thanks to God.

"The tears rolled down his face as big as large peas. He asked me if

I had told the Queen, and if there was any danger in telling her. I said: 'No,' but I begged His Majesty that this should be done with as little emotion as possible. He went over and kissed the Queen and said to her: 'My dear, you have had great pain, but God has been very good to us in having given us that which we asked of Him — we have a fine son.' The Queen clasped her hands together and lifted them, with her eyes, towards heaven, bursting into tears, and then became very weak.

"I asked the King to whom he wished me to give Monsieur le Dauphin, and he said: 'To Madame de Montglas, who will be his governess.' Mlle de la Renouillière took the Dauphin and carried him to Madame de Montglas.

"The King then went over to impress the princes with the weakness of the Queen, then opened the bedroom door and invited in all the people that were out in the antechamber and the grand cabinet. I believe there were two hundred persons, so that one could not move through the room to carry the Queen to her bed. I was infinitely angry at seeing this. I said there was no reason for everyone coming in here; that the Queen was not yet through her confinement. The King heard me and tapped me on the shoulder and said: 'Keep still, keep still, midwife — don't be angry — this child belongs to the whole world, and everyone must rejoice over him.' It was half past ten o'clock at night, Thursday, the 27th of September 1601, day of St. Cosme and St. Damian, nine months fourteen days after the marriage of the Queen.

"The valets de la chambre of the King and Queen were called. They carried the obstetrical chair near the bed, and the Queen was then moved. Something was administered to her for her weakness, and having given her the service which was necessary, I took charge of Monsieur le Dauphin whom Madame de Montglas gave back to me. M. Hérouard commenced then to wait on the child. He bade me wash it entirely in wine and water, and to look it all over before I bandaged it. The King brought up the princes and several noblemen to see it; all those belonging to the household of the King and Queen saw the child and then made places for others. They all were so glad they could scarcely express themselves. They embraced each other without regard to who they were; they were so transported with joy they did not know what they did. I was told that through the entire town all night there were bonfires and the noise of trumpets and drums. Casks of wine were broken open, to be drunk to the health of the King and Queen and the

Dauphin, and the messengers were sent out post-haste to all foreign countries to carry the news, and through all the provinces and towns of France.

"As soon as the Queen was put to bed, the King had his bed made near to hers, where he lay down to see that all went well with her.

"The next day after dinner I found M. de Vendosme alone at the door of the antechamber, holding aside the curtain of the cabinet through which one passed to go into the room of Monsieur le Dauphin. I stopped, very much astonished, and I said to him: 'What are you doing there, monsieur?' He said: 'I do not know — scarcely anyone talks

Delivery in the obstetric chair. After Rueffius. 1637.

to me — no one says anything more to me.' 'That, monsieur, is because everyone goes in to see Monsieur le Dauphin, who has just arrived. When everyone has greeted him, they will speak to you, as formerly.' I told this to the Queen, who felt very sorry for him, and said: 'Behold, this kills the poor child,' and ordered that everyone should caress him, as formerly. 'Everyone is taken up with my son, and no one thinks of him, and that seems very strange to this child.' The kindness of the Queen was always very great.

"The 29th of this same month I went to see Monsieur le Dauphin; the page, Brir, opened the door for me. I saw the room full; the King, Madame his sister, the princes, and the princesses were there, because

they were just going to baptize Monsieur le Dauphin. I was about to retire, but the King saw me and said: 'Come in, come in, you need never stay out.' He then said to Madame and the princes: 'I have seen many persons, but I never have seen any so resolute, be it man or woman, in war or elsewhere, as is this woman here; she held my son in her lap and looked at the whole world with those eyes as cold as if she held nothing at all instead of a dauphin, and it has been eighty years since one was born in France!' I replied to this, 'I have said to Your Majesty, Sire, that it was necessary for the health of the Queen.' 'That is true,' said the King, 'and I did not tell it to my wife until it was all over, so that the joy would not upset her. Never a woman did better than you did; if you had done any different, my wife would have died. Hereafter I shall always call you Ma Résolue!'

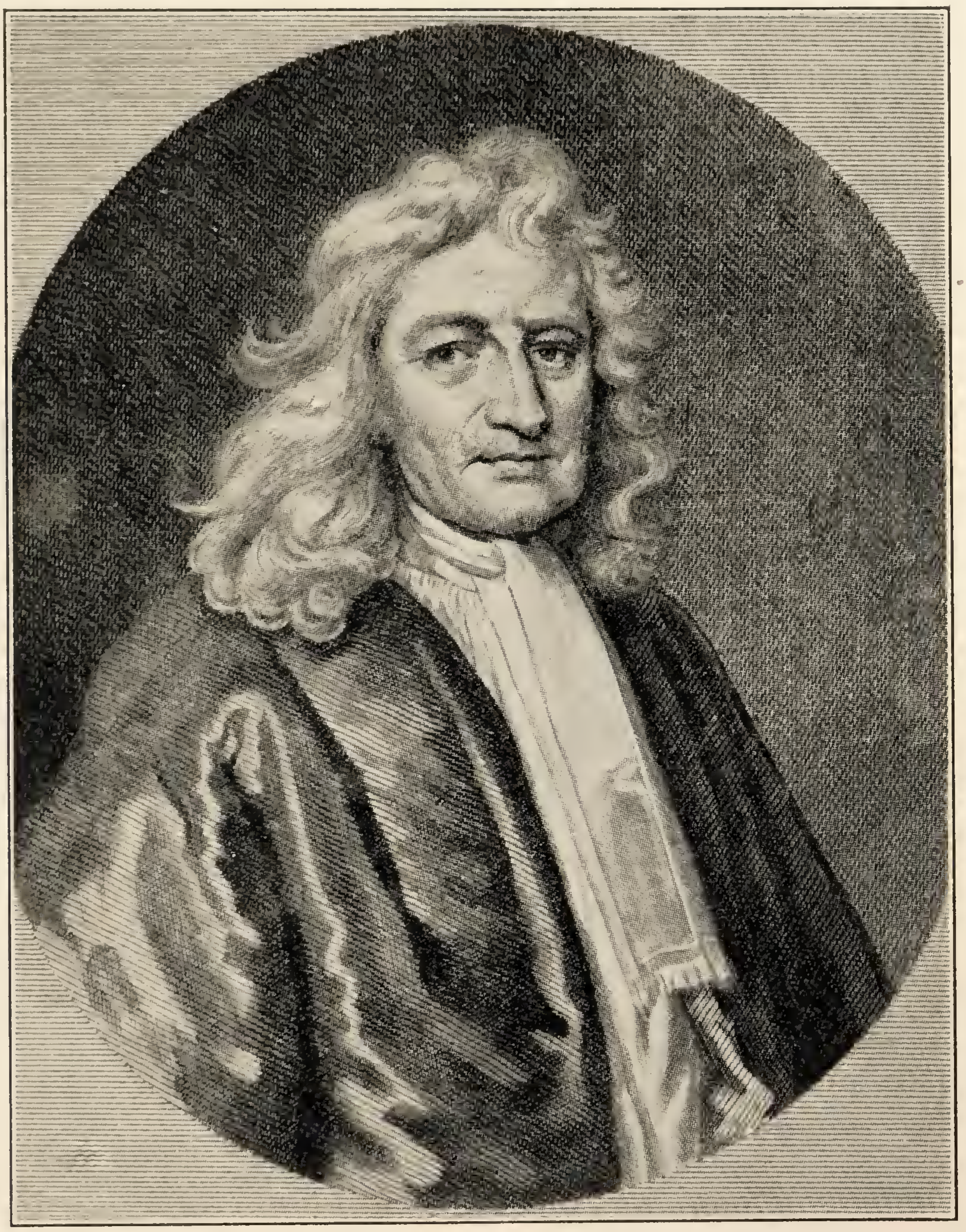
"The King did me the honour to ask if I wished to be the nurse of Monsieur le Dauphin and said that I could have the same wages as the wet nurse. I begged His Majesty to allow me to continue my profession, so that I would always be more capable of serving the Queen, and so that he would always have near her an honest woman who understood her well. I remained near the Queen to serve her bed one month, then eight days afterwards, awaiting the return of His Majesty from Paris, who had asked me to wait for him."

We may now return to Hugh Chamberlen, whom we left standing outside St. James's Palace.

The rise of the Chamberlen family, their acceptance as accoucheurs by persons of all ranks due to their "family secret," which was nothing more or less than the obstetric forceps, was roughly coincident with the replacement of the midwife by male obstetricians in the conduct of pregnancy and labour. The histories of the two movements — the introduction of the obstetric forceps and the usurpation by men of the work of the midwife — are almost equally bizarre.

After the establishment of a scientific anatomy by Vesalius, and the beginning of a physiology by Harvey, the practice of obstetrics could no longer remain a separate "trade" practised by apprentices. Men, with minds more alert than women's, became interested in this part of the workings of the body, and through their studies the first real advance in its practice was made. Walter Needham, as noted before, in

1667 described clearly the purpose and function of the placenta: to convey the nutriment in the mother's blood to the growing child. The discovery could never have been made without the inspiration of Har-



Peter Chamberlen, the inventor of the most useful of all surgical instruments. (See notes in bibliography.)

vey's work on the circulation of the blood; when it was made an enormous jungle of speculation and stupid practice was cleared.

The effect of Paré's popularization of podalic version was an immediate increase in the number of men practising obstetrics. First, the mere matter of superior physical prowess operated in this direction. Podalic

version is hard work. " There are those," said Francis Mauriceau, " who believe it an easy matter to deliver a woman because women practise it," and he goes on to controvert this view. " When the child is drawn forth . . . sometimes great strength is required, which will often make him sweat in the midst of winter because of the difficulties of this labour more than all the rest."

Men midwives, advised Mauriceau, should have " small hands for the easier introduction of them into the womb when necessary, yet strong and the fingers long, especially the forefinger. He must have no rings on his fingers, and his nails well pared . . . have a pleasant countenance and be as neat in his clothes as in his person, that the poor women who have need of him be not affrighted at him. Some are of the opinion that a practitioner of this art ought on the contrary to be slovenly, at least very careless, wearing a great beard to prevent the occasion of the husband's jealousy that sends for him."

Not the least of the objections to the entrance of men into this feminine field came from the midwives themselves. They did not welcome the gentlemen with any graciousness whatever. In England they attempted, without success, to obtain a royal charter and form a guild. When the scheme failed, they turned to vituperation. The men who did obstetrics were ridiculed and called men midwives and mid-men. And, as a particular instance of her virtuosity in refined Billingsgate, a certain Mrs. Elizabeth Nihell called William Smellie (1697–1763), who was the greatest obstetrician of his day, " a great horse godmother of a he-midwife."

But by 1700 the male obstetrician was solidly established. In France, Mauriceau (1637–1709) was the leader. The attendance of men at the accouchement of queens set the fashion definitely.

It is not surprising that in such an atmosphere the Chamberlen family should rise to great prominence and popularity. Hugh Chamberlen's father and grandfather were physicians, and, in turn, his own sons practised medicine in England. The professional life-span of the family extended from Queen Elizabeth to George III.

Mauriceau published a book which was among the earliest of the scientific treatises on obstetrics. In 1672 Hugh Chamberlen translated this book into English, and in the translator's preface Chamberlen makes this significant announcement:

" My father, brother, and myself (though none else in Europe as I

know), have, by God's blessing and our own industry, attained to and long practised a way to deliver women in this case [that is, difficult labours] without any prejudice to them or their infant, though all others (being obliged, for want of such an expedient, to use the common way) do, and must, endanger, if not destroy, one or both with hooks."

Mauriceau had indeed heard of this "secret" and had invited Chamberlen to demonstrate its operation in Paris.

"On the 19th of August 1670," says Mauriceau, "I saw a small woman, aged thirty-eight, who had been in labour of her first child for eight days. The waters escaped on the first day without hardly any dilatation of the os. She remaining in this condition until the fourth day, I was sent for, and recommended the midwife to administer an infusion of senna to excite pains, which she had not; this was done the following day and succeeded in causing pains, by which the mouth of the womb was dilated as far as possible. Nevertheless, I could not deliver, and the child had remained in the same situation, without being able to advance, for this woman was so small, and the bones [of the pelvis] so narrow that it was quite impossible to introduce the hand to deliver her, although mine is small enough . . . or to introduce the fingers sufficiently to enable me to use a crochet safely, so as to extract the child, which had been apparently dead for about four days. I declared the impossibility of delivering this woman to my assistants, who, being well persuaded of this, prayed me to perform the Cæsarean operation, which I would not undertake, knowing well that it was always certainly fatal to the mother. But after I had left the woman in this condition, it not being possible for me to help her as I would any other of a more normal conformation of body, there came shortly afterwards an English physician named Chamberlen, who was then in Paris, and who, from father to son, made a profession of midwifery in England, in the town of London, where he thus acquired the highest reputation in that art.

"This physician, finding the woman in the condition just stated, and learning that I had not found any possibility of delivering her, declared himself astonished that I could not do so. *Moy* [says Mauriceau, with all a Frenchman's untranslatable vanity] *qu'il disoit assuroit estre le plus habile homme de ma profession qui fort a Paris;* notwithstanding which he at once promised to deliver her most assuredly in less than a quarter of an hour, whatever difficulty he might find. Accordingly,

he immediately applied himself to the business, and instead of a quarter of an hour he worked more than three entire hours without cessation, except to take breath. But having vainly exerted all his strength as well as all his industry, and seeing that the poor woman was almost dead in his hands, he was obliged to abandon the attempt and to allow that he could not accomplish it, as I had well declared. This poor woman died undelivered twenty-four hours after the violence he had done her, and at the examination I made in performing after her death the Cæsarean operation, which I would not do before, as I had said, I found the child and everything else as I had before stated, and the womb all torn and pierced through in several places by the instruments which this physician had blindly used without the control of his hand, which, being a size larger than mine, he did not seem to have been able to introduce sufficiently far so as to preserve it."

This failure did not interfere with the popularity of the "secret." Chamberlen continued to make use of it. The female public continued to call him in for that purpose. And all other practitioners, male and female, continued desperately to try to find out what the secret was. But Hugh Chamberlen had a great command of language — he kept it all to himself. He did not divulge the secret.

This attitude is generally regarded by medical writers as a lasting stain on the honour of the Chamberlen family. The profession today holds as its most sacred obligation the principle that any method of diagnosis or treatment shall be shared freely by the discoverer or inventor with all his fellow-practitioners, without regard to personal gain. Thus in the case of such recent discoveries as insulin, and liver extract, and viosterol, no attempt was made to patent them for commercial exploitation although such a procedure would have been perfectly legal and the enormous intrinsic value of the methods would have resulted in incalculable wealth to the discoverers. This point of view is obviously no more than simple humanity: methods to relieve human distress must not be allowed to have any taint of profit about them — must be given openly. But such standards are obviously again the sign of an enlightened morality. They did not obtain in Chamberlen's time; the medical profession was then not closely organized for the protection of the whole population; secret remedies were the rule, were held and guarded by far more eminent practitioners than Hugh Chamberlen.

The story is what we are here concerned with. How did the great

secret get out? A truly great secret, because the obstetric forceps has been called "the most valuable of surgical instruments."

The forceps were probably invented by Peter Chamberlen, the father of Hugh. He was one of the great eccentrics of his time. He frequently proposed to incorporate the midwives. He had ideas on phonetic writ-

The man midwife. Eighteenth-century cartoon.

ing (for example, "nite" for "night"). He wished to reconcile all the Churches. He anticipated motor-cars, at least to the extent that he was excitedly interested in "Coaches, Waggons, Carts, Plows, etc., to go by Engine without horses" and driven by wind, and "able to Navigate with all winds in a Straight Line."

Hugh, succeeding to his business and much of his nervous tempera-

ment, made and lost a fortune and was finally compelled to return to Holland "on suspition of debt." At Amsterdam he evidently felt that the best way to relieve his straitened circumstances was to sell the family secret. The negotiations are very obscure, and at this date we cannot tell exactly what happened, except that it looks like dirty work at the cross-roads.

The secret was sold to a Roger Roonhuysen, who carried on a monopoly in the forceps trade for many years. The firm was called the Medico-Pharmaceutical College of Amsterdam, which as late as 1746 decreed that no physician could enter practice until he had bought for two thousand gulden one of the instruments. The attitude of the college justly caused great indignation. Someone said that he who kept such a secret "deserves to have a worm devour his vitals for all eternity."

In 1753 or 1754 two public-spirited citizens, Jacob de Visscher and Hugo van der Poll, decided that trade in such a necessary instrument was disgraceful. They therefore pretended that they wished to engage in obstetrics, attended the Medico-Pharmaceutical College, and bought the secret in the ordinary way.

Then they announced it to the world.

But either they were duped by the college, or Hugh duped Roonhuysen, or Roonhuysen duped all his disciples, because the secret, when Visscher and Poll gave it to the world, was only one blade of the obstetric forceps. This, however, did not do any harm, as the two-bladed forceps was being used in England and knowledge of its mechanism rapidly became general in the civilized world.

CHAPTER X

THE PRACTICE OF MEDICINE

1. *Observation — Sydenham*

Young Hans Sloane stood irresolutely before the great man's house. He was back in London and the year was 1684. His friend and benefactor, Robert Boyle, the chemist, had advised him to go and talk to Thomas Sydenham. Sydenham was, in Boyle's opinion, the greatest physician in England; indeed, in the world.

"He's not popular with his brother practitioners," Boyle acknowledged, "and he has a vile temper, but he's not carried away with a whole storm of theory."

Hans smiled at this pronouncement. For, in an age of theories, Dr. Boyle had announced himself as "the sceptical chemist," and depended on experiments to learn the truth.

The world was full of ideas in that busy seventeenth century. And especially in England, now that the war was over and Charles the Martyr had been killed, and Cromwell was dead, and Charles II on the throne. Men were no longer in fear either of the Church or of the State. People were not burned or tortured for holding opinions.

Indeed, opinions were encouraged. They were encouraged so much that many, like Sydenham and Boyle, thought they were in danger of being mere theory with no corporeal existence at all. The Royal Society had been founded in London to investigate nature, and it was a needed influence. Theories somehow died out under the withering criticism of the debates in the society. Antonj Leeuwenhoek, a Dutchman, had reported to the fellows a queer instrument he had invented — a glass affair that enlarged objects — a microscope. We have already heard about that. Another Dutchman, Regner de Graaf, was doing

some very strange things. He thought women laid eggs, like hens, only not outside the body. The German, Glauber, called roundly "an arrant knave" by Oliver Cromwell, had discovered a salt that had marvellous properties. A Dane named Stensen had made all sorts of interesting observations, one of which was to show that the saliva came into the mouth through a little tube or duct from the gland at the angle of the jaw. Oh, it was a great time to be alive! But still young Hans Sloane thought a man must have some sort of a theory. It's all very well to have facts, but there must be a theory to hang the facts on — to correlate them.

But which theory to accept? There were so many of them. The favourite for the moment was probably the iatro-chemical school of the Belgian, van Helmont. Its real founders were the great French philosophers Descartes and Pascal, and the Englishmen Newton and Hooke.

These men had put all nature on a mathematical basis.

Newton and Descartes had shown that so much of nature was geometrical that man could not help supposing the actions of the body responded rigidly to mathematical laws.

Van Helmont expounded the iatro-chemical doctrine thus: every process of the body is presided over by a special archeus or spirit. He called these blas. All physiological processes are chemical, and the different gases or blas get mixed up, and different arrangements of them produce different diseases.

But van Helmont had been dead forty years when young Hans Sloane stood outside Sydenham's house, and a man's theories begin to weaken after he dies and is no longer vocable to defend them.

So Hans Sloane thought he would go and find out what Thomas Sydenham had to say.

He was admitted to the house by Sydenham's apprentice and student — the only one he had, for, as Boyle cautioned young Hans, he was not popular.

"There's an evil-looking fellow," thought Hans Sloane to himself, and indeed a more unprepossessing countenance you could hardly find in all London than that which adorned Sydenham's assistant.

Sloane asked politely for Dr. Sydenham and delivered up the note Dr. Boyle had given him, and the fellow bade him wait and shuffled into the back regions for his master.

In a moment or two the door from the hall opened and the old Roundhead soldier stood before him—a tall, heavy man with a magnificent massy face, leaning on a cane, for he was badly afflicted with gout.

"Well, sir, so you know Robert Boyle," he said bluntly, indicating the letter of introduction he carried in his hand.

"I have that honour," answered the young Æsculapian.

Portrait and title-page from Thomas Sydenham's Practice of Medicine.

"And John Locke—do you know John Locke, too?"

"I have met him."

"You have met a great man, sir; John Locke's conversation is the most elegant and the most fruitful of any man's in England—Robert Boyle alone excepted. But sit down, sir, sit down."

"So you have a mind to practise physic, eh?" he said after they were seated.

"I have studied at Paris and Montpellier and graduated from the University of Orange," answered young Hans.

"Montpellier, eh?" responded the older man with a smile. "I have been once to Montpellier myself. How looks Montpellier now?"

"It is still beautiful, sir, and the nightingales still sing in its woods."

"Ay, and the French mademoiselles still roam the streets, I suppose, and spread the lues venerea," laughed the old man, grimly.

"Well," he continued, "I see by this letter that you are, so Robert Boyle says, a ripe scholar, a good botanist, and a skilful anatomist."

Hans assented modestly and began eagerly to tell of his collection of plants, thinking to ingratiate himself with the great man.

But he was suddenly interrupted.

"This is all very fine, but it won't do," the gouty old fellow stormed. "Anatomy — botany — nonsense — sir, I know an old woman in Covent Garden who understands botany better than you or I, and as for anatomy, my butcher can dissect a joint full as well as we can. No, young man, all that is stuff. There is only one place to learn disease; you must go to the bedside."

So that was the great principle of Thomas Sydenham's life, Hans Sloane learned. Well, he agreed to try the idea and study under him.

"Good," assented the choleric master. "Here, I will introduce you to my assistant — your fellow-worker." The youth with the evil countenance entered in response to a bell. "This is Thomas Dover," said Sydenham; "he will instruct you for a while: he is a deep well, is Thomas Dover — he knows a deal about certain things, such as opium and ipecac, I can tell you, though he will probably die on the gallows."

So the greatest of observational physicians, the first of modern practitioners, is said to have looked and talked.

Here is the essence of Sydenham, of whom it is said that he was the greatest physician since Hippocrates!

He taught that you can tell one disease from another because the course of each is different; their appearances are different, and so you must watch them. He worked long before the days when the particular germs of diseases were known, before you could differentiate one disease from another by finding and identifying the germ. Or before the days when bodies were opened after death, and the changes carefully compared. Long before the days when the microscope was perfected and tissues put under the glass, and the cells of one disease shown to be different from those of another.

Sydenham advocated letting nature take its course and watching disease as it progressed.

"At the bedside," he said to young Hans Sloane. And there all medicine begins still. Unless your doctor has observed disease at the

Thomas Dover's most famous exploit — the rescue of Robinson Crusoe. Dover was captain of the ship which found and removed Alexander Selkirk from the island of Juan Fernandez, February 2, 1707 (old style). This was during Dover's career as a "pirate" — he helped finance an expedition to pillage the South Seas. Afterwards he returned to London and engaged very successfully in practice and published a book: The Ancient Physician's Legacy to His Country, *in which he described Dover's powder, a medicine still used. (By courtesy of Dr. Edwin Leonard —* Pharmacal Advance)

bedside, he is not much of a doctor. If he merely knows about microscopes and culture tubes and X-ray machines, he will not help you much. But if he has watched sick people through their diseases and

asked them questions, found out where the pain is, and found when and how and why it went away, he is a safe man to anchor to.

Here is a sample of Sydenham's description of a disease — tuberculosis:

Phthisis

"The cough betrays itself. The phthisis comes on between the eighteenth and thirty-fifth years. The whole body becomes emaciated. There is a troublesome, hectic cough which is increased by taking food and which is distinguished by the quickness of the pulse, and the redness of the cheeks. The matter spit up by the cough is bloody or purulent. When burnt it smells fetid. When thrown into water it sinks. Night sweats supervene. At length the cheeks grow hard, the face pale, the nose sharp. The temples sink, the nails curve inward, the hair falls off, there is colloquitative diarrhœa, the forerunner of death."

And here is his differentiation of measles and scarlet fever, not easy for anyone to make:

Measles

"The measles generally attack children. On the first day they have chills and shivers, and are hot and cold in turns. On the second they have the fever in full — disquietude, thirst, want of appetite, a white (but not a dry) tongue, slight cough, heaviness of the head and eyes, and somnolence. The nose and eyes run continuously; and this is the surest sign of measles. The symptoms increase till the fourth day. Then — or sometimes on the fifth — there appear on the face and forehead small red spots, very like the bites of fleas. These increase in number, and cluster together, so as to mark the face with large red blotches.

"2. The spots take hold of the face first; from which they spread to the chest and belly, and afterwards to the legs and ankles. There is slight cough, which, with the fever and the difficulty of breathing, increases. There is also a running from the eyes. On the sixth day, or thereabouts, the forehead and face begin to grow rough, as the pustules die off, and the skin breaks. About the eighth day they disappear from the face, and scarcely show on the rest of the body. On the ninth, there are none anywhere."

Scarlet Fever

"Scarlet Fever (Scarlatina) may appear at any season. Nevertheless, it oftenest breaks out towards the end of summer, when it attacks whole families at once, and more especially the infant part of them. The patients feel rigors and shiverings, just as they do in other fevers. The symptoms, however, are moderate. Afterwards, however, the whole skin becomes covered with red maculæ, thicker than those of measles, as well as broader, redder, and less uniform. These last for two or three days, and then disappear. The cuticle peels off; and branny scales remain lying upon the surface like meal. They appear and disappear two or three times."

Notice the important elements in those descriptions. They are among the masterpieces of medical literature. They were the record of Sydenham's own original observations. They are the first accurate descriptions of these diseases.

And just as Vesalius in anatomy and Harvey in physiology laid the foundations of the *science* of medicine, so these descriptions of Sydenham founded the *practice* of medicine.

Note first that there is no theory in them. They have the authentic ring of fact. Sydenham has actually watched cases of measles day by day — he tells you what happens the first day, what the second, and how many days the disease lasts on the average.

Then note the vividness of the descriptions. That likening of the eruption of measles to the appearance of flea bites is a stroke of genius. It is still copied into text-books. The eye involvement, the cough — he has it all in.

Then, he is not trying to establish how he influenced the course of the disease by treatment. He is not touting for any remedy. He is a natural scientist, observing a natural phenomenon.

All clinical medicine began again with Thomas Sydenham. Everything of which we moderns are so proud — laboratory examinations, bacteriological examinations, all the cumbersome paraphernalia of practice — is mere embroidery on that solid core of substance which is good bedside observation.

2. *Scientific Examination of the Sick Body — the Pulse*

Galileo Galilei was attending service at the Cathedral of Pisa (the date was *circa* 1581). He was not much interested in the sermon or the prayers, but his attention was directed to a chandelier which swung backwards and forwards above his head.

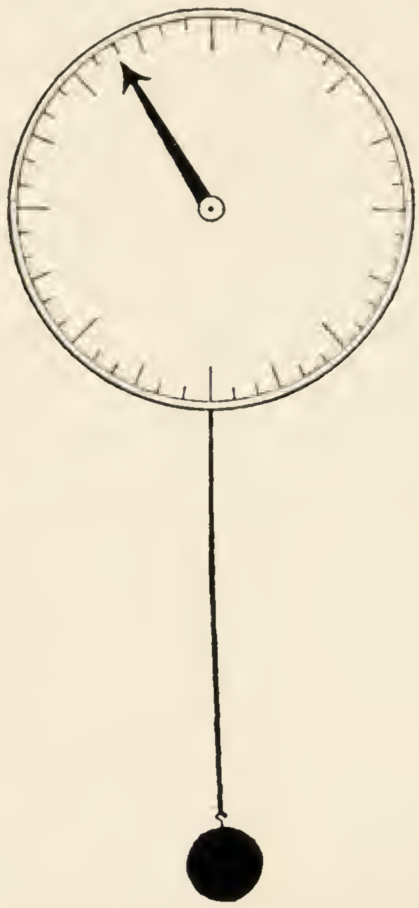
The lack of interest Galileo displayed in the blessed mutter of the mass that day in the Cathedral of Pisa has worked entirely to our benefit. Galileo was the scion of a noble Tuscan family and had become a student of medicine at the University of Pisa, much to his father's disgust, because the paternal desire was to make a cloth-merchant out of him. He was to live to plague both his father and the dignitaries of all Italy, first by dropping weights from the leaning bell-tower at Pisa (which made him look a fool to his father) and then by inventing a telescope with which "His Serenity and all the members of the Senate" (of Venice), after having "ascended at various times the highest bell-towers in Venice to spy out ships at sea making sail for the mouth of the harbour," could see them clearly, though "without my telescope they would have been invisible for more than two hours." His final outrage against public decency, of course, was to assert that the earth moved round the sun.

But all this was in the future. He was a raw young medical student there in the Cathedral of Pisa when his roving eye lit upon that oscillating chandelier. It moved backwards and forwards like a pendulum in swings of ever decreasing amplitude. But what occurred to Galileo was that he thought he could calculate that even when the amplitude of the oscillation was the narrowest, the time consumed in the small swing was the same as the time consumed in the long swing. This seemed queer: there was nothing like it in Aristotle he was sure; but was it true? Galileo had no watch. No one had a watch in those days. As he cast about for something to confirm his suspicions, his fingers lit upon his pulse. Perhaps in the excitement of being on the verge of a discovery the young medical student felt his own heart beating, and that suggested a timing piece.

At any rate, there he is — gazing upward, open-mouthed, hand on wrist, while all about him the pious are crossing themselves and telling their beads.

Now! The chandelier swings — one — two — three — in three beats of his pulse. And back — one — two — three. Now several minutes later. See, the arc of the swing is much smaller now — you can see the corner of that window beyond its left-handed excursion, which you could not do before. But as to timing — one — two — three, and back — one — two — three. Just as before.

Galileo Galilei walked out of the cathedral into the bright sunshine which was beating then, as now, upon those white marble stones, and



Galileo's pulsilogium. By pulling the weight up or down until it swung synchronously with the pulse of the patient under observation, the pulse-rate was recorded above on the dial, which was numbered (numbering not shown in this diagram). (From Hart: Makers of Science. *Oxford University Press)*

he began to think. He was by occupation a medical student, so part of his thoughts concerned his pulse, this perfectly regular chronometer inside his body. There was food for thought there. But Galileo at the bottom of his soul was a mathematician. And mathematics has to do with time and weight and length of arc — all the things which seemed so mysterious about that chandelier. Heaven only knows how many

people before him had seen chandeliers swinging in cathedrals without ever thinking of any relationship between those curious ponderables — time and weight. We, in this age, live very much by time. But the existence of time was less imminent in the days of Galileo. It was only because his mind was that of a natural mathematical genius that he began to analyse these relationships. Thus from Galileo's thoughts two ideas sprang — one concerning the timing of the pulse and one the relation of a pendulum's weight and arc to the period of its swing.

He went home and began to experiment. He tied a weight on a string and found by exact measurements that his calculations in the cathedral had been correct. The pendulum swung through narrow arcs at the same rate of time that it did through wide ones. But he found that if he lengthened the pendulum it swung through its arcs at a slower rate. So much for the mathematicians.

Then the medical student came to the fore. He began comparing his own pulse under different conditions — after running and at rest — and found it varied. Then the pulses of his friends — old people and young people. There were variations here, too.

So he constructed the first instrument with which to measure the pulse — Galileo's pulsilogium. It was a very simple contrivance, based on his string and weight idea. The string wound up on a wheel behind a dial. The dial had a pointer on it. When the pendulum swung synchronously with the patient's pulse, the pointer indicated the rate at which that pulse was going.

It was long before this idea of Galileo's began to be used as a practical thing, in medical diagnosis. The age was not ripe. Although Galileo's great contemporary Kepler used his pulse to record astronomic observations.

When Galileo went to the University of Padua as Professor of Mathematics, in 1592, he had many talks with the Professor of Medicine there, Sanctorio Sanctorio, usually known as Sanctorius.

Sanctorius had a number of curious ideas. He wanted to measure the body's changes — not guess at them.

One day he called Galileo over to his laboratory with a very mysterious air. He showed a puzzling-looking contrivance — a long, twisted glass tube surmounted by a bulb on the end (the bulb a little bigger than a golf-ball). He filled the tube up with liquid and immersed the other end in a beaker of the same liquid. Then he invited

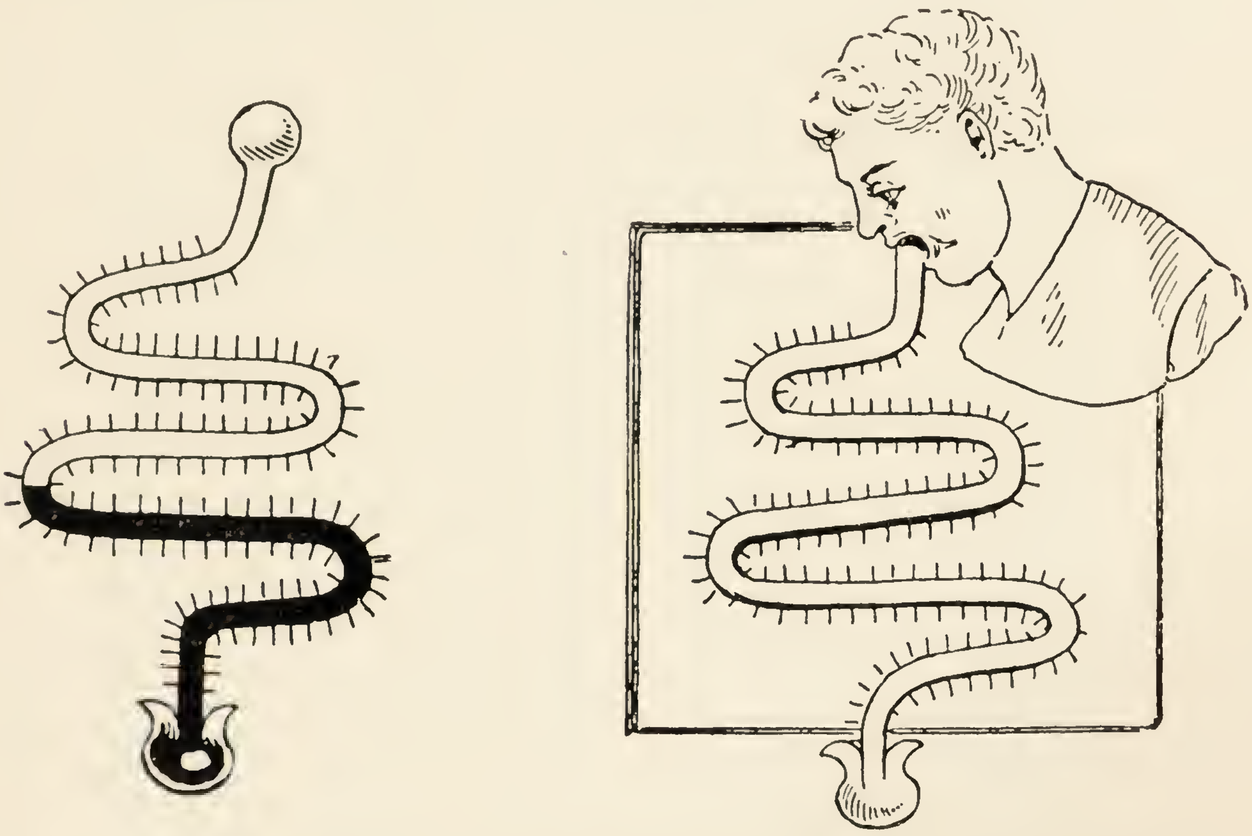
Galileo to enclose the bulb with his mouth. Galileo did so. The fluid began to descend the tube into the beaker. Finally it came to a standstill.

"Animal heat," Sanctorius explained.

He had demonstrated the first clinical thermometer.

But that was not the end of Sanctorius' measuring of the body. Not only did he measure the pulse-rate and measure the heat of the body; he measured its weight.

He was consumed with curiosity about the mysterious way in which the body lost weight.



The mouth-thermometer of Sanctorius (to the left) and the mouth-thermometer of Sanctorius in action (to the right).

He constructed a steelyard, or scales, to weigh himself. It was so made that he could balance himself exactly on it, sitting in a chair, and have a table of food brought before him. No matter how exactly he had balanced himself, as soon as he had eaten some food the end of the steelyard on which he was sitting sank. This was natural. The explanation was easy. The food he had eaten had weight, and when it was transferred into him, it gave him extra weight.

All right. But here was the rub. He could weigh the food and know exactly how much he took in. Then he could weigh his urine and fæces and know exactly how much he had cast out. But they were not the same. And his body did not gain the difference day by day, but stayed the same.

What the devil had happened? Where was the loss?

It took a long time to answer that puzzle of Sanctorius', and the modern science of nutrition was founded in the process. Sanctorius himself answered it in a somewhat facile manner. He said the difference was in "insensible perspiration."

"If eight pounds of meat and drink are taken in a day, the quantity that usually goes off by insensible perspiration in that time is five pounds," says his sixth aphorism.

Which shows that he was a careful observer.

His second aphorism says: "If a physician who has the care of another's health is acquainted only with the sensible supplies and evacuations and knows nothing of the waste that is made daily by the insensible perspiration, he will only deceive his patient, and never cure him."

Which shows he was an astute physician.

Sanctorius, in fact, was years ahead of his time.

To return to the counting of pulses, we must take up the early illness of a little boy named Samuel Johnson, who lived in Litchfield in England.

He was afflicted with some swellings on his neck. His doctor was a John Floyer, who pronounced the trouble the king's evil and sent him to London on one of the days when Queen Anne was touching for the Evil.

"I was taken in Lent to London to be touched by Queen Anne" — you will find the account written in Johnson's own hand in the house in Litchfield. — "I remember a boy crying when I went to the Palace to be touched. I always retained some memory of this journey though I was then but three years old." And Boswell says that Doctor Johnson, being asked if he could remember Queen Anne, answered that he had "a confused, but somehow solemn recollection of a lady in diamonds with a long black hood." The great lexicographer carried to his dying day "abiding testimony of Anne's ineffectual handiwork."

In spite of his superstitious belief in the power of kings to cure by touch, Sir John Floyer was an ingenious man. He became absorbed in the idea that the counting of the pulse could be made to tell a good deal about the body in sickness or in health.

Floyer says in the introduction of his book that he "tried pulses by

the minute in common watches and pendulum clocks and then used the sea minute glass."

We may imagine him starting to count a pulse and turning an hour-glass upside down, counting the pulse until the sand had all run out. Science stumbles painfully along to its technical perfections.

The beginning of calories and scientific dietetics. Sanctorius in the steelyard. He is weighing himself before and after a meal.

"At last he was more happy. One Daniel Quare, a Quaker, had in the last years of the 17th century put on watches what Floyer called a middle finger, or, as we say, a hand.

"Floyer's pulse watch ran 60 seconds and, you may like to know, can be had of Mr. Samuel Watson in Long Acre.

"And now follows pulse of age and youth, pregnancy, exercise and sleep. And we learn how diet, blisters, and the weather affect the pulse." (Weir Mitchell — see Bibliography.)

But notice that here we have the science of diagnosis in the making. Floyer is setting down standards for us — the standard of normal pulses. The abnormal will come later. But we cannot be sure what is

One of the earliest examples of the physician's pulse watch. Circa *1700. It has a second-hand. Ever since Sir John Floyer invented this, all sorts of people have second-hands on their watches, but almost none but physicians utilize them.*

abnormal until we know what is normal. All diagnosis rests on such fundamental knowledge.

So today there is a second-hand on the face of your watch. It was put there by Sir John Floyer for the use of physicians only. And if you come to think about it, unless you are a physician you have no earthly use for it.

The next figure in the history of pulse-counting is Robert James Graves. You might see him often on the streets of Dublin a hundred years ago, a tall and distinguished figure, making his way to the Meath

Hospital. Dublin was the great centre of all European medicine at this time. And Graves was its most distinguished medical ornament. One of his great descriptive feats was his account of that disease which usually goes by his name — Graves' disease — exophthalmic goitre — rapid pulse, staring eyes, tremor, and enlargement of the thyroid gland.

Among his many contributions to clinical medicine was the practice he introduced of counting the pulse by the watch. And he put it on a more scientific basis than had Floyer. He made regular records and watched the outcome of his patients so studied. It was Graves who established the science of pulse-counting so that, as Weir Mitchell says, " the familiar figure of the doctor, watch in hand, came to be commonplace."

PART IV

THE FUNDAMENTAL SCIENCES ADVANCE

While all these methods of treating the sick were being perfected by barber-surgeons, midwives, and apothecaries, men were learning more and more about the world around them. They investigated air, water, earth, and fire — motion, machines, stars, magnets, seeds, animals, plants, rocks, rivers, winds, sun, and moon.

And since we all belong in the one universe together, a great deal of this information was useful to the students of the body. So we must pause to see what fundamental scientific discoveries prepared the way for new conquests of man's ancient foe — disease.

CHAPTER XI

A NEW SCIENCE — "THE SEATS AND CAUSES OF DISEASE"

The grey city of Padua has grown old in service to the art of medicine. It is over two hundred years since Vesalius was elected the first Professor of Anatomy in the university — over a hundred years since William Harvey studied there. And now, in the middle of the eighteenth century, another great man is seeking truth within the shelter of its hallowed walls.

On this warm spring day he is walking slowly to attend his lectures. He turns into the ancient courtyard, ablaze with its rows of stemmata on the walls. He is dressed in his academic robes — the curled wig falling to his shoulder, the plain white jabot, the long robe with the green chevrons on the sleeves. Dignified, his strong patrician, darkly Italian face breaks into a smile as the students doff their caps to him, and in his faintly satirical, aristocratic manner he returns their salutations with brief familiar chaffings.

Giovanni Battista Morgagni, Professor of Anatomy in the University of Padua, begins his demonstration on the dead body before him. But, strangely enough for a professor of anatomy, he is not interested in the natural or normal anatomy of the parts. He is interested in a condition plainly the result of disease — a great swelling in the aorta (the large blood-vessel which rises from the heart).

" It was said aforetime, gentlemen, in the days of my great predecessor, Vesal, that it was a wise thing to utilize the bodies of criminals who had been hanged to study the parts of the body.

" And, doubtless, so it was in that time, when men knew little of such things, and when prejudice was opposed to opening the body after

death for observation. But as the famous Dr. Harvey, who once sat upon the benches where you now sit, and who doubtless learned more here than he ever acknowledged — as he so well says, what can you learn from the body of a man hanged about the diseases which afflicted him through his life — for he had no disease until just at the instant of dissolution? How much better to dissect the bodies of these whom we have observed closely in life and who were afflicted with disease and died of it, when we have noted all those symptoms of which they complained, and by dissection can explain the cause thereof, and show the seats.

"And now, indeed, people no longer have a prejudice against such inquiry — and even great and true churchmen are willing that such be done. Did I not recount to you the result of the examination of the body of Cardinal Antonio Francesco Sanvitalis as made by my master, Valsalva? And who can doubt that my lord Cardinal was a great and good man and understood the doctrines of the Church when his officers consented in his name to this examination?

"Now, see, what have we here? This man I knew well. He was a native of Beluna, in the territories of Venice. His business was to shear woollen cloth with shears that were pretty large. Whether from that heavy labour, or from drinking, or the venereal disease, he began about a year ago to have a tumour arise in the right and upper part of his chest.

"Now, we hear much of the seats and causes of disease, gentlemen. There is van Helmont, who is held in much esteem with his iatrophysics, and blas, and the worthy Descartes, with his internal fires and misplaced juices of the soul, and the acid-alkali balance of Sylvius, and the phlogiston of the excellent Stahl.

"Now, where is all this talk of humours, of blas, of phlogiston? The learned doctors said the symptoms this patient suffered were due to misplaced humours. Yet I find no humours. I find a dilatation of the great blood-vessel. It swelled and swelled, this aneurysm did, it pressed on the heart and the lungs, and finally it swelled until its walls became so thin it burst — and then the patient died. Why could not the swelling of this vessel have caused the symptoms — why must we prate of humours when we can find none? Why does not my observation explain all we need to know about the cause of the disease?"

So Giovanni Battista Morgagni goes on to teach his classes about diseases.

In the midst of the lecture a messenger tiptoes in and whispers to the professor.

"Ah! So," he answers, his eye glinting with anticipation. "Now, they tell me that a worthy citizeness of this city of Padua, a nun whom

Giovanni Battista Morgagni (1682–1771).

I saw only yesterday, has died. She had a pneumonia, gentlemen, and I will show you that this science is able to predict the changes in the body when one knows the symptoms aforehand.

"Listen closely to her symptoms: She was seized in the night with fever with which she shivered.[1] . . . After an interval of twenty-four

[1] The shivering was the chill which almost invariably signals the onset of pneumonia.

hours a pain on one side of the breast[1] was added to the fever, and a cough quite dry,[2] and a hard pulse. Death occurred on the seventh day.[3]

"Let the body be dissected!" he commands the messenger. "It will certainly be found that the lungs have the substance of liver. Go and see for yourselves." He dismisses the students.

They crowd out and view the autopsy on the nun. They are delighted to find that the changes in the lungs are exactly as Professor Morgagni described them.

All his life Morgagni made these observations. But he did not rush into print with them. The shaded walks were very pleasant about the ancient University of Padua. It was agreeable to teach his classes leisurely — to make notes on his patients, to see as many dissections as possible. He prized the powerful and noble among his friends. "A woman of Padua, by name Jacoba, the wife of Angelo Zanardi," he writes — "finding thirteen ribs on each side of her body, I inquired out her name and noted it down, something I am not accustomed to do among the common people."

He was seventy-nine years old before the epoch-making book, which ensures his enduring fame, was published, in 1761 — *De Sedibus et Causis Morborum — On the Seats and Causes of Disease.*

He preserves the pleasant fiction that this work was begun as a series of letters to a young medical friend, designed to lead him to proper ideas about the seat and the cause of different diseases. It spun out, this correspondence, into three enormous volumes.

How closely he showed that the symptoms during life could be connected to and caused by the changes seen after death!

Take one short description. Dumas might have written *Camille* from it:

"A strumpet, about twenty years of age, had laboured many months under a slow fever, a cough, an ill-conditioned expectoration, and a wasting of the whole body. She complained of a pain in the left part of the thorax, so that she could scarcely bear to lie down upon it. She was troubled with a difficulty of breathing. To which was added a copious spitting of blood; but this being checked, and two days after,

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[1] Pain in the side — a regular symptom of pneumonia. See how faithful Morgagni's descriptions are.

[2] Dry cough. The cough of pneumonia seldom brings up sputum.

[3] Seventh day. One of the critical days for pneumonia.

a south wind blowing hard, in which state of air those who labour under a similar disorder, for the most part, perish, death put an end to her disease.

" The right lobe of the lungs adhered very little to the ribs. Both of them abounded with hard tubercles, which inclined to a white colour and resembled glandular bodies. The right lobe, towards the sternum,

The anatomical theatre at Padua in the time of Morgagni.

contained a large hollow ulcer, and in this a purulent matter; but the left, towards the side, contained a hard substance, equal to the bigness of a large pear, which, in some measure, resembled the substance of the pancreas when indurated; and in the middle of this substance was a small ulcer, full of pus."

He knew, and he described once and for all, pneumonia. In that disease the lungs, instead of being like a sponge full of air sacs, become

solid. As we have seen, he even predicted how they would look in the case of the Paduan nun.

Apoplexy cases particularly interested him. Over and over again he showed that when a person is suddenly paralysed down one side, the brain will show a hæmorrhage on the side opposite. Go back to the old medicine man in the first chapter who knew that a wound on one side of the head caused paralysis on the opposite side of the body; but he ascribed it to wide-wandering devils. What a long path we have gone since then! Morgagni knew, or suspected, that the nerves from one side of the brain crossed over to the muscles on the opposite side of the body. He explained the phenomenon of crossed paralysis without invoking devils.

What were these collections of pus or inflammation around the brain? That also interested him. Wild wandering humours, said the theorists. "Well, why then," asked Morgagni, "is there always pus in the ear, too, when these things are found?" He showed the very path through which the pus got from the ear to the brain.

His pathology was a living, dynamic thing. Disease grew and moved just as life did. Disease was a part of the order of nature. Pious people who said that disease was unnatural — a sign of God's anger — obtained only his scorn. Disease, said Morgagni, was just as natural as water running downhill was natural.

CHAPTER XII

THE LIVING MACHINE

1. *The Breath of Life*

The "Invisible College" was to meet that evening, as usual, in the rooms of Dr. Wilkins, warden of Wadham College, Oxford. It was June 1657.

That stammering scion of Irish nobility, the Honourable Robert Boyle, seventh son of the Earl of Cork, had already arrived and was leisurely instructing his familiar, Robert Hooke, in setting up the apparatus for the evening's experiments.

The "college" was held in considerable awe by the other students and residents of Oxford, many of whom were still sufficiently unemancipated from the spirit of the Middle Ages as to believe that its members were engaged in the study of the Black Art. They met so quietly, almost secretly, and said so little about their affairs that the suspicion gained credence. And the sight of queer flames leaping up and illuminating the windows of the apartment where they met, an occasional muffled explosion, and various hammerings from time to time, lent it colour.

But, in point of fact, the meetings were conducted with due regard for order and propriety. The members themselves called their club the "Philosophical Association," and their object was to study nature by the new philosophy of *experimentation.*

Mr. Christopher Wren was the next arrival, and he tweaked the Honourable Robert by the ear, saying: "What tonight, me braw bhoy?"

"'Twill d-d-develop, you d-d-d-d-damned astronomer," returned the nobleman.

"By heaven, you double d-d-d-damned me that time, Robert! I invited Thomas Willis to come over," announced Wren. "I've been making some anatomical drawings for him — base of the brain. He's got some interesting ideas."

Other members drifted in — Richard Lower, ushered in by the host, Dr. Wilkins, and after nearly a dozen more the great Dr. Willis, leading a shy young boy named Mayow by the hand, whom he apologized for, saying he was a youth interested in natural philosophy.

"William Harvey is dead," announced Dr. Willis suddenly, when he had seated himself.

Exclamations of regret and sorrow came from all.

"I got the news by messenger from London today," affirmed the doctor, nodding. "It is, of course, quite to be expected — the poor old man was nearly eighty. But it makes me heavy quite the same. A very great man, sirs."

"I know how you feel, doctor," said Robert Boyle, referring to the fact that Willis had studied with the dead master. "I had the same feeling when G-Galileo died in Florence during my residence there."

"But what have you been doing of philosophic interest, doctor?" the host asked.

"I have been much interested, gentlemen, in the curious disease called by the ancients 'diabetes,' on account of the accident of having two patients with that affliction under my care."

"We would be interested, I am sure, in your observations," encouraged Dr. Wilkins.

"Why, 'tis not much, perhaps, but it is a curious thing why these people lose so much flesh and why, at the same time, they pass so much urine. It would appear, indeed, that they actually waste their flesh away and pass out the waste in their urine. So it occurred to me it would be an interesting thing to find out what it was that was in this urine — salt, or sulphur, or what. And I determined to find out by a very simple device." He paused for his effect, and when he saw he had their full attention, he concluded: "I tasted it."

"B-B-Brave bhoy!" cried Robert Boyle in admiration, and Christopher Wren chuckled.

"Well, gentlemen, 'tis honey — naught else. As sweet as ever can be — with maybe a bit of a salty or pricking taste along with it. Now, isn't that a matter to explicate for you — I am worse off than I was before — why should the melting down of the body be naught but honey?"

Since this was a chemical question, and all these philosophers were interested in the changes which matter undergoes in nature, it was eagerly discussed for a space.

And then Robert Boyle and Robert Hooke exhibited their apparatus, which was a kind of pump and a curved glass tube with a column of mercury in it. Their experiments had to do with some curious properties of the air.

"That the air has weight and spring to it," as the Honourable Robert put it.

The ring of eyes watched him eagerly as he demonstrated how the column of mercury could be made to move simply by pressing air against it, and that the column of air in the short sealed end of the tube could not be compressed into nothingness even when twenty-nine inches of mercury was poured into the long side.

"So the air we breathe is something — not impalpable," said Richard Lower in his deep, grave voice, during the course of the discussion. "It must be true — else why is the act of breathing everywhere an essential part of life? Next to the motion of the heart and blood, which our dead master Harvey made clear, it is the invariable essence of life."

"What, then," he continued, and he posed the second great fundamental problem of physiology, "What, then, does the air do? What is the essential essence of it — because we breathe it out as well as breathe it in?"

"Is it not for the ventilation of the heart?" inquired Dr. Willis, sententiously.

"That is, of course, the common view," responded Boyle. "But there is another opinion touching respiration which makes the genuine use of it to be ventilation, not of the heart, but of the *blood* — in its passage through the lungs, in which passage it is disburthened of those excrementitious steams proceeding, for the most part, from those superfluous serosities of the blood."

And as they sat silently and gravely pondering these momentous words, he added:

"A flame cannot burn long in a narrow and close place — it needs air of an ambient and yielding nature. So doth the vital fire in the heart."

Many of them in that company were to add bits of facts to the demonstration of that great truth. The "Invisible College" of 1645–60 was

to become the Royal Society for Improving Natural Knowledge, and its transactions hum with these experiments.

Robert Hooke, in 1667, showed that the act of respiration, of moving the chest up and down, is only of secondary importance, and that by blowing air in and out of a dog's lungs with a bellows the dog could be kept alive indefinitely.

Robert Boyle himself showed, on October 1, 1678, that a mouse put in a receiver "fortified against the external air" would die in about an hour, and that if, after it were dead, another mouse was introduced into the receiver in such a way as not to allow any external air to enter also, the second mouse would die in three minutes.

John Mayow, the shy boy who attended the Invisible College with Dr. Willis, showed the mechanism of respiration in 1668.

He recognized first that the air contains what he called a vital substance. He named it "saline vital air" because it exists in salt nitre. He stated that it was necessary for all acts of combustion or burning.

He placed a lighted candle in an inverted bell-jar over water and saw that as the candle became extinguished, it exhausted some portion of the air in the bell-jar, because the water rose inside the glass container. He repeated the experiment with modifications to determine whether combustion would take place after the vital spirit had been exhausted. He arranged the bell-jar and candle as before, but added an easily combustible powder on a metal plate inside the bell-jar. Before the candle was lighted, he showed that he could ignite the powder through the glass with a burning-glass — that is, a lens which concentrated the rays of the sun on the powder. If he allowed the candle to burn out, he could not ignite the powder with his burning-glass as before.

Lastly, he showed that an animal by breathing will exhaust the vital spirit just as does a candle by burning. He placed a mouse inside a bell-jar, the under opening of which was covered with a sheet of elastic bladder. As the mouse breathed, the bladder was sucked into the inside of the bell-jar. The mouse was raised upon a rounded elevation of the bladder, showing that the animal's breathing exhausted some substance from the air. Modifying the experiment, he showed that a candle will not burn in a closed bell-jar after an animal has died from suffocation inside.

Theorizing from his experimental work, Mayow came to the "bold,

but correct view " that the air loses a part of itself inside the lungs and that that part is absorbed by the blood and carried round the body to keep up the animal fire.

Richard Lower, in that great tract *Tractatus de Corde,* published in 1669, showed that the blood changes from a black to a red colour in the lungs *"from the air mingling with it."*

He showed that blood would do the same thing when removed from a vein in the body and exposed to the air. Venous blood would

John Mayow, a neglected medical genius.

turn to arterial blood before your eyes. "The surface of venous blood which is put onto a plate only takes on a red colour because it is exposed to the air, and this is further proved by the certainty that if this surface were skimmed with a knife, that which is immediately underneath would be changed in a short time to the same colour by a similar contact with the air."

Thus the second major generalization in physiology was proposed. The first was the circulation of the blood. This second was the function of respiration.

The men who first attacked the problem were not professional scientists in the modern acceptation of the term. This is worth noting, because for two hundred years we find the foundations of science being laid entirely outside academic circles. Wren was an architect; Boyle a man of leisure — a member of the aristocracy. Hooke was his secretary. Lower, Willis, and Mayow were practising physicians. They found time to do their experiments in the spare hours of busy lives.

During the seventeenth and eighteenth centuries this was the rule. The universities were still devoted to classical learning; science and experiment were regarded as rather " low " — beneath the notice of a gentleman. But curiosity in the ways of nature could not be stifled, and every alert mind dabbled a little in investigation. Ministers, farmers, sailors, animal-breeders experimented on weather, lightning, fermentation, heredity, and all kindred subjects. The aristocracy were as likely to be interested in barometers or fulcra as today they are likely to be interested in politics.

The problem of the relation of the air to life fell into some neglect after the work of the members of the Invisible College. It came up against the stumbling-block of the composition of the air. That is to say, it came up against the stumbling-block of analytical chemistry. It is very easy for us today to say glibly that the air is composed of oxygen, nitrogen, carbon dioxide, traces of argon, krypton, etc., but suppose you were set down in the eighteenth century without a modern text-book of chemistry or any apparatus; how would you prove it?

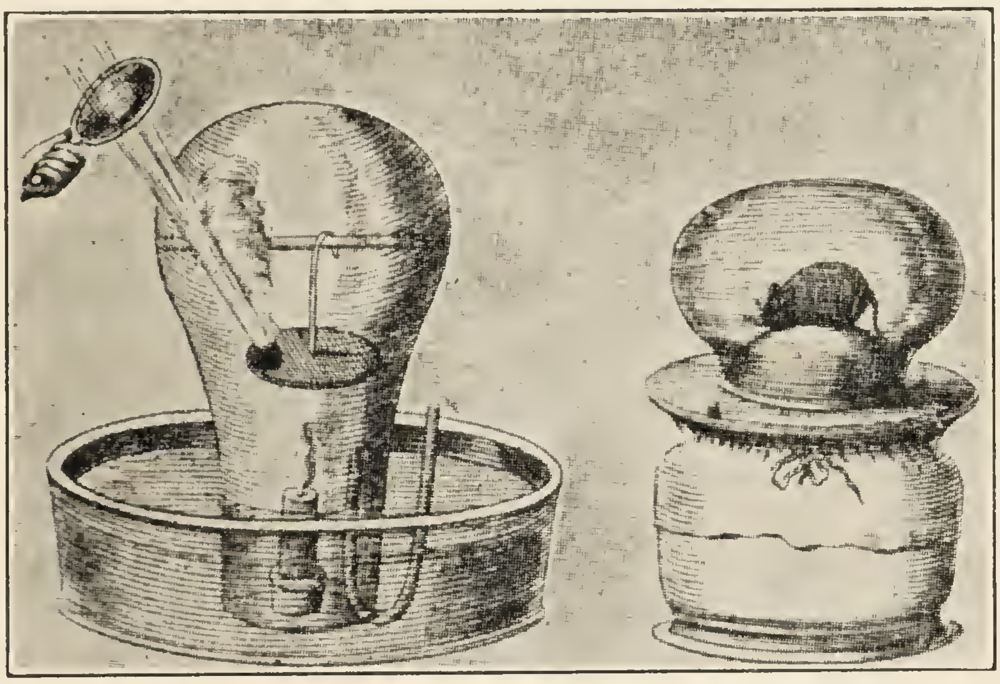
Not only air, but fire and heat and water and earth were problems. We regard heat today as a form of energy; but the seventeenth-century theory regarded it as a substance which they called phlogiston. Did not wood diminish when fire was removed from it?

The mystery of the nature of these fundamental substances was not unravelled for nearly a hundred years after the days of the Invisible College, through the work of an Edinburghian who wore tin boots, a British nobleman of excessive eccentricity, a minister who lived next to a brewery, a poverty-stricken Swedish apothecary, and a French politician.

The Edinburghian who wore tin boots was Joseph Black (1728–99). He isolated carbon dioxide, which, of course, is one of the constituents of air. Black called it " fixed air." He also showed that if chalk is heated,

it loses weight, a refutation of the phlogiston theory, because according to that doctrine the heat added to the chalk should increase its weight. Black's work was published in 1755. People were learning slowly but steadily about the air. By breathing through a glass tube into a basin of lime-water, Black showed that chalk was precipitated, which proved the presence of carbon dioxide in expired air. His tin boots were the predecessors of our overshoes.

The nobleman of excessive eccentricity was Henry Cavendish (1731–1810), who proved that water was not an element, but was composed



Mayow's experiments with air.

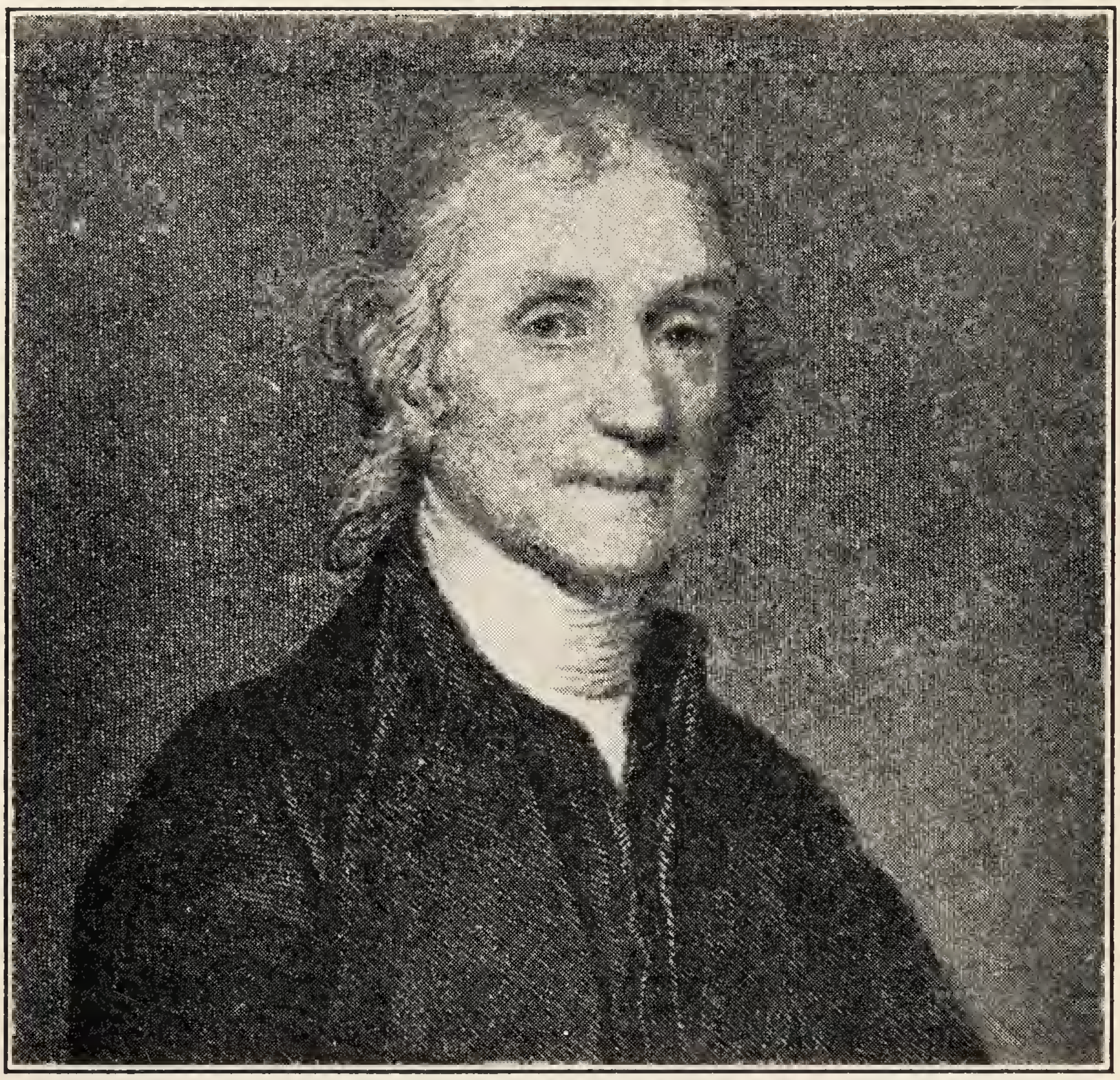
To the left, a candle is burned in a bell-jar inverted over water. Mayow arranged this experiment so that some powder which could be ignited with a sun-glass was suspended above the candle. He showed that after the candle had exhausted the oxygen in the bell-jar, the powder would no longer ignite.

To the right, Mayow's experiment to show that an animal in breathing exhausted the air just as a candle does in burning. The mouse is placed on an elastic diaphragm, and as it exhausts the air in the bell-jar, the diaphragm rises.

of hydrogen and oxygen. The conclusive experiment made by Cavendish was to pass an electric spark through a closed jar containing oxygen and hydrogen, when drops of water would be formed. His reputation for eccentricity seems to be based on nothing more than that he avoided society, remained unmarried, wore shabby clothes, and died rich.

The divine who lived by a brewery was Joseph Priestley (1733–1804). Priestley was always a non-conforming sort of person. Educated for the ministry, he drifted through several changes of faith and finally ended as a Unitarian. As the incumbent of a Unitarian pulpit in Birmingham

he was a man of prominence in the community, a community which afforded a Lunar Society, which met at the near-by city of Leamington and among the members of which were, besides Priestley himself, James Watt, the inventor of the steam engine, Erasmus Darwin, the grandfather of Charles, William Withering, who first described the medicinal properties of digitalis, and Matthew Boulton, the partner of James Watt, who produced a new copper coinage for Great Britain. Priestley's political opinions were quite as radical as his theological doctrines and



Joseph Priestley, a Unitarian minister who lived by a brewery discovered oxygen.

in 1791 his sympathy with the French Revolutionists led to his house being entered by a mob, who burned it and destroyed his library, scientific apparatus, and experimental notes. Following a series of such persecutions, he sailed to America and lived here nearly ten years, dying in 1804 at Northumberland, Pennsylvania. His portrait, painted by Gilbert Stuart, bears such a striking resemblance to the same artist's representations of Washington as to raise wonder whether the master did not become confused.

Priestley's residence by a brewery interested him in the nature of the gas given off in fermentation. This he determined to be carbon dioxide, or Black's fixed air. While experimenting on this he isolated oxygen or "dephlogisticated air," as he called it. This was on the 1st of August 1774, when he extracted a gas from *mercurialis calcinatus per se.* What surprised him "more than I can express was that a candle burned in this air with a remarkably vigorous flame."

"It is this ingredient in the atmospheric air," he wrote, in 1794, "that

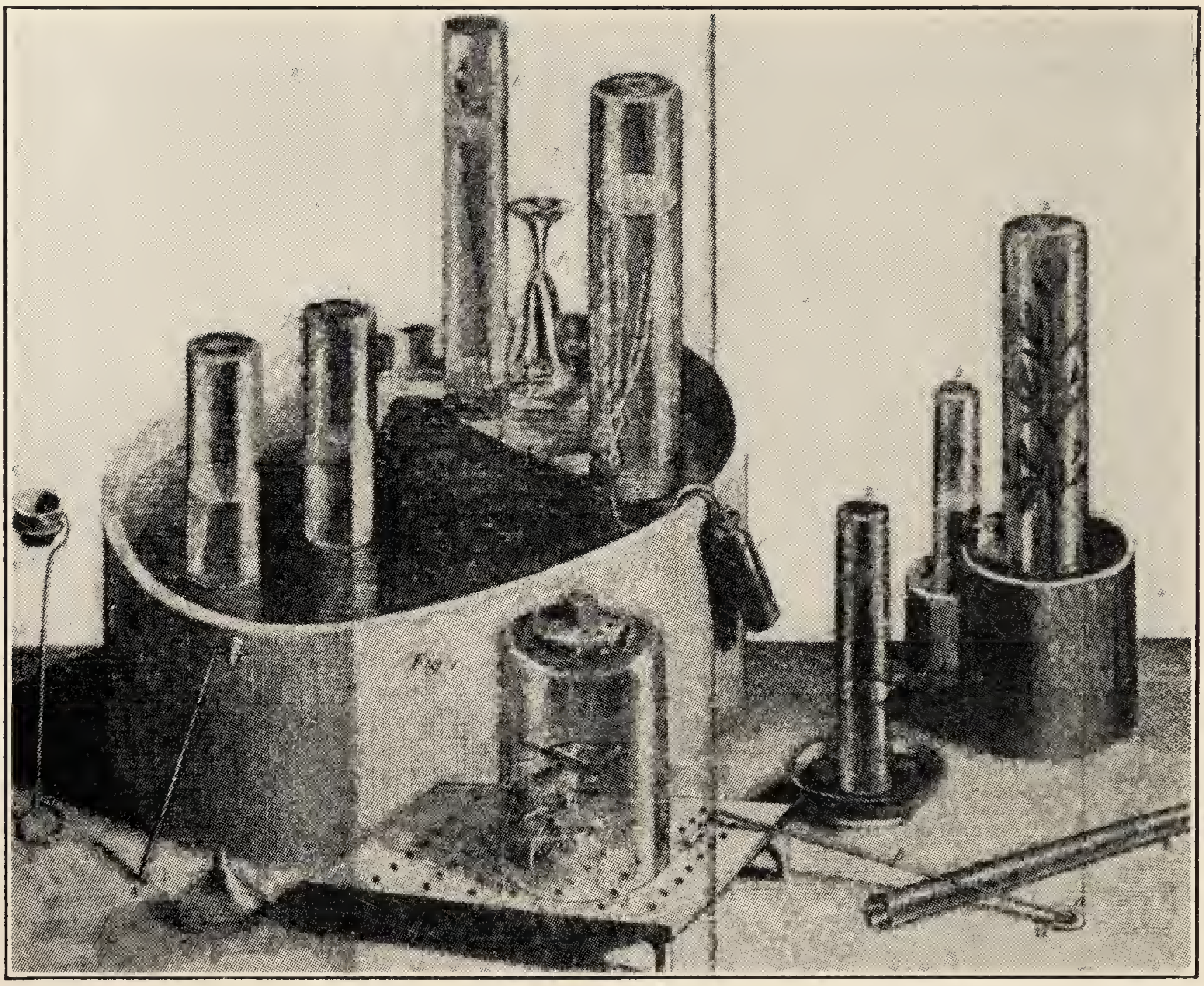
The mob destroying Priestley's house, during the French Revolution. Priestley's liberal views so enraged his fellow-townsmen that they burned and sacked his house.

enables it to support combustion and animal life. By means of it most intense heat may be produced and in the purest of it animals will live nearly five times as long as in an equal quantity of atmospheric air. In respiration part of this air passing the membranes of the lungs unites with the blood and imparts to it its florid colour, while the remainder, uniting with phlogiston exhaled from venous blood, forms mixed air. It is dephlogisticated air combined with water that enables fishes to live in it."

In short, Priestley had discovered oxygen.

The Swedish apothecary was Karl W. Scheele (1742–86). Priestley's prior claim to the discovery of oxygen is disputed by Scheele's admirers. His book on *Air and Fire* was published in 1777. He obtained oxygen from saltpetre and called it fire-air.

By the French politician I mean, of course, Lavoisier (1743–94). He dabbled only gingerly in politics; most of his devotions were given to



Priestley's experiments to show that a fire burning uses up the same substance from the air that an animal uses when breathing; and that plants give it off. He called it "dephlogisticated air." It is, of course, oxygen.

scientific research. How gigantic and serene he appears beside those trumpery and mouthing blackguards that history likes to consider the important figures of the Revolution — beside Robespierre, and Marat, and Danton! *"Il ne leur a fallu,"* remarked his colleague Lagrange, when that head fell beneath the guillotine, *"qu'un moment pour faire tomber cette tête, et cent années peut-être ne suffiront pas pour en reproduire une semblable."*

In chemistry Lavoisier's was one of the supreme minds of all times.

Younger than any of the men whose work I have just described, he was able to systematize their data and to discard their errors. He had a genius for devising experiments which would establish truth and reveal falsehood. He cast out the phlogiston theory from the body of chemical doctrine. He named oxygen, isolated it, probably independently of

Lavoisier in his laboratory. He isolated oxygen and described its function in respiration. (From a picture in the Sorbonne)

Priestley, and described its properties. In 1777 he published a paper: "Experiments on the Respiration of Animals and on the Changes which the Air Undergoes in Passing through the Lungs." Except for one slight error, corrected by his friend Lagrange, whose eulogy on him we have just recorded, this paper expounds the essential doctrines of respiration as we know them today — that blood sent out to the

tissues gives up some of its oxygen to them and absorbs carbon dioxide, thus becoming dark or venous blood; that this venous blood, returning to the right side of the heart, is forced into the lungs, where, through

Statue of Galvani, at Bologna in front of the old Anatomical Building of the Medical College. The book, or tablet, at which he is gazing is a dissection plate, and, although they cannot be seen in the photograph, a pair of frog's legs are sculptured upon it.

the thin membranes of the lung alveoli, it gives off the carbon dioxide it absorbed in the tissues and reabsorbs oxygen, becoming red or arterial blood again.

2. *Frogs' Legs*

Aloysio Galvani was preparing a dainty dish of frogs' legs for the lovely Lucia.

He was devoted to Lucia, and no wonder, because not only was she the embodiment of all feminine grace and beauty and perfection, but she had been sent to Aloysio by Heaven itself — directly.

He had gone to church in that high city of Bologna with the leaning towers. And he had prayed for a wife — fervently he had prayed. And as he raised his eyes from their devotional attitude, they encountered the lovely features of Lucia Galleazzi.

Married they were, and after so direct an intervention by Heaven it is no wonder that they lived happily ever after.

Galvani was appointed Professor of Anatomy in the University of Bologna.

There in the midst of all this success and happiness the lovely Lucia became indisposed; the young professor good-naturedly offered to prepare frogs' legs to entice her invalid appetite. He severed the legs from the body of the freshly killed frog. He removed the skin — with a pair of forceps and scalpel, as an anatomist should. The scalpel in his right hand, the forceps in the left.

Suddenly the professor's sharp eyes noticed something. What was that? The handle of the forceps and the handle of the scalpel clicked, and as they touched, the frog's muscle twitched.

"A dead frog?" Galvani said to himself. "A dead frog's muscle twitching? And why?"

Whether or not the lovely Lucia got her supper that night we do not know. Certainly you may be sure the young professor sat long into the night thinking over the strange phenomenon he had invoked. The incident changed his whole life, and the rest of it was devoted to twitching frogs' legs.

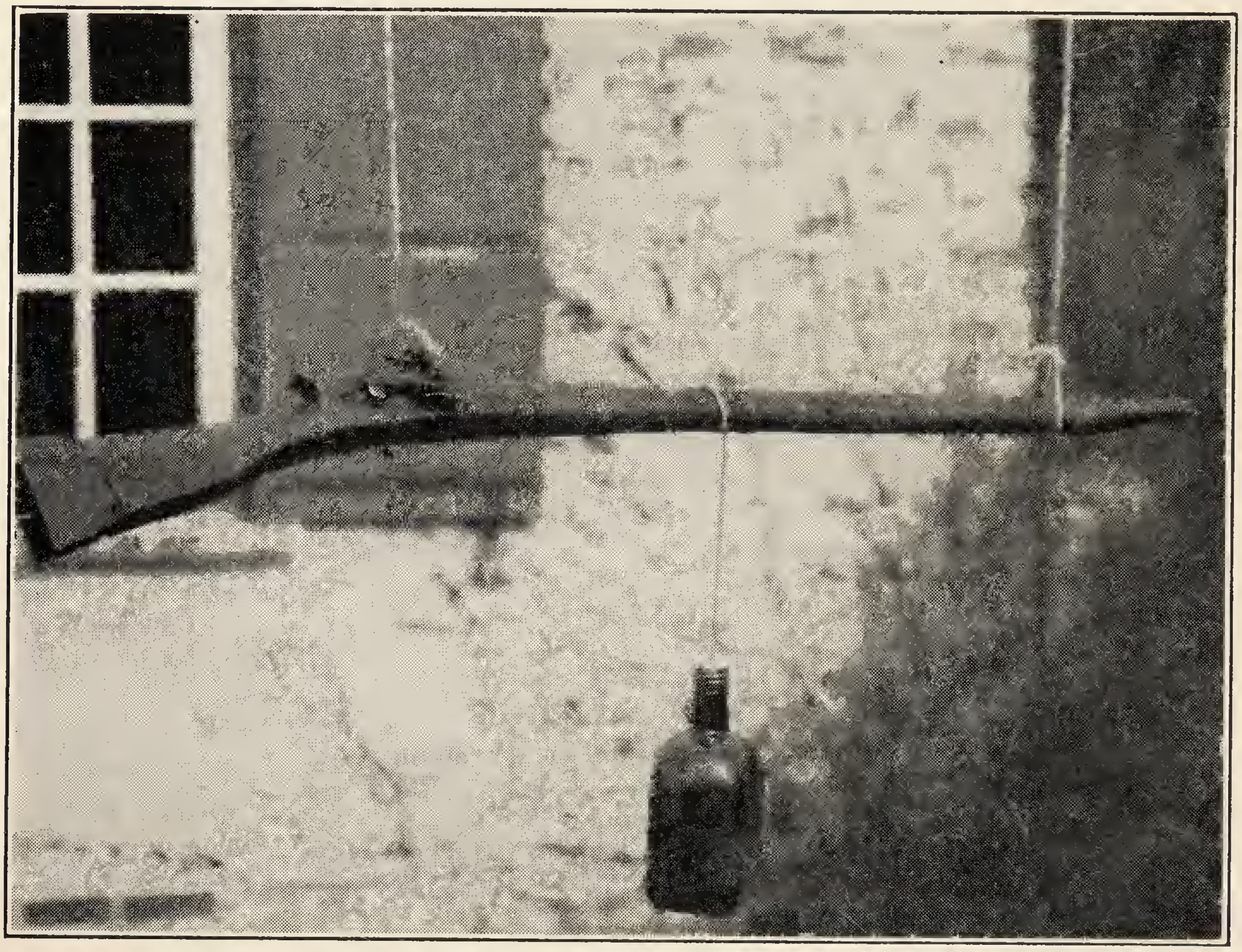
Two streams of thought went through his mind. Being a professor of anatomy, he naturally thought of the cause of muscular movement.

But even more dominant was the idea of electricity.

The whole scientific world was then dabbling in electricity. In Leyden, Pieter van Musschenbroek had shown that electricity can be stored in a bottle of water suspended from a gun-barrel by a metal wire

passing through the cork of the bottle. The gun-barrel was itself suspended by a silk thread, so that the entire apparatus was attached only to non-conductors of electricity. When Pieter placed one hand on the gun-barrel and the other on the bottle, he received a shock.

The Abbé Nollet, whom we shall meet in the chapter on X-rays, repeated the experiment, passing a shock through a line of the King's Guards holding hands, in His Majesty's presence. Then through a long



The Leyden jar. Pieter van Musschenbroek showed that electricity can be stored in a bottle of water suspended from a gun-barrel by a metal wire passing through the mouth of the bottle.

line of Carthusian monks, who gave a sudden spring when the contact was completed.

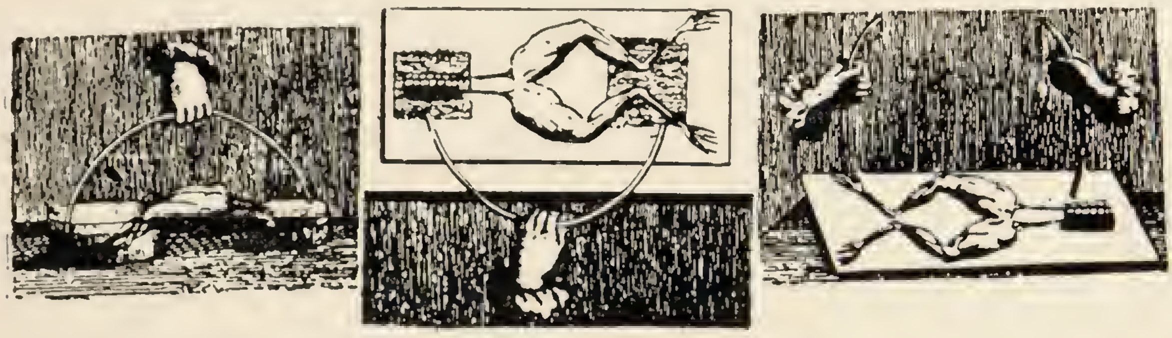
Similar experiments are still done. In compliment to the city of its origin, the bottle apparatus has ever since been known as a "Leyden jar."

Benjamin Franklin worked with "M. Musschenbroek's wonderful bottle" and suggested the terms "positive" and "negative" electricity, in 1750.

It was natural, then, for Galvani to think of electricity when his frog's leg twitched. He had electrical apparatus in his laboratory. To

judge from the illustrations in his book, there must have been plenty of frogs around Bologna. He began his experiments.

" I dissected and placed a frog on a table on which was an electrical apparatus. One of those who were helping me accidentally touched with the point of his scalpel the nerve of this frog's leg, and suddenly all of the leg muscles appeared to be contracted; they seemed to have fallen into fairly tonic convulsion. Another who was helping seemed to observe that the phenomenon was produced while the spark was obtained from the conductor of the machine."



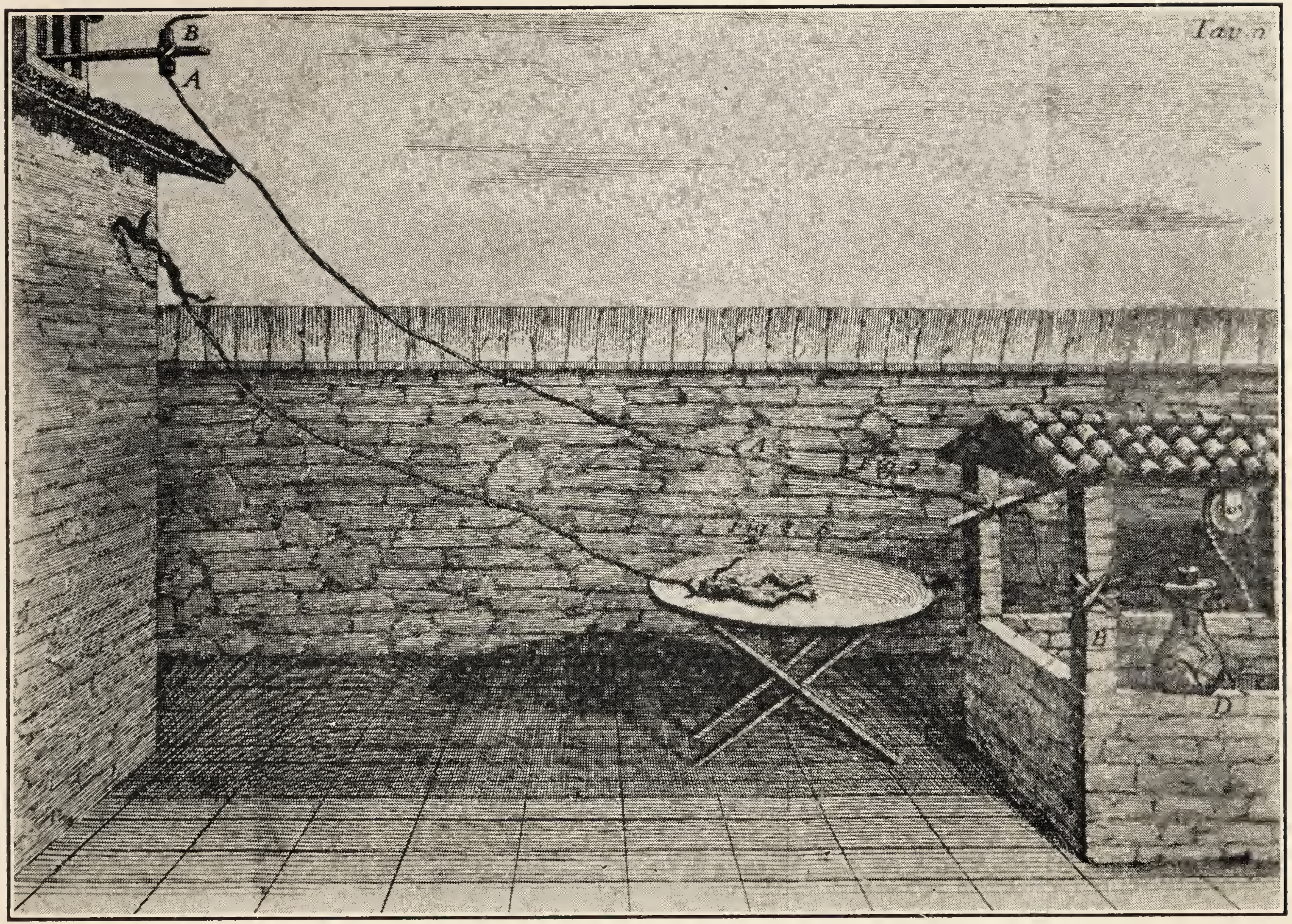
Galvani's experiments showing the power of metallic contacts to move the muscles of a dead frog. 1792.

For twenty years Galvani worked on these things. He hung frogs' legs in the courtyard of his home, suspended by copper hooks from an iron wire, and watched them during thunder-storms. They twitched always then, but also on clear days whenever the atmospheric electrical charges became high. He found that when he put a nerve in contact with animal tissue at two points, one injured and the other uninjured, the muscle supplied by the nerve would be thrown into contraction.

From this Galvani evolved his theory of "*animal magnetism,*" which held the imagination of his time. Animals were resources of electrical energy — such was the central theme of Galvani's theory.

He made many mistakes in the interpretation of his results, mistakes which were corrected by his countryman Volta. Volta, who remains the eponym of the volt and who engaged in an acrimonious debate with Galvani, utilized Galvani's basic ideas to construct the voltaic battery and pile with a series of disks of different metals.

" Who," says Helmholtz, " when Galvani touched the muscles of a frog with different metals and noticed their contraction, could have dreamt that all Europe would be traversed with wires, flashing intelligence from Madrid to St. Petersburg with the speed of lightning? In the hands of Galvani and, at first, even in Volta's, electrical currents



Galvani's experiments with frogs' legs. From De viribus electricitatis, *1791.*
(By courtesy of Dr. W. W. Francis, Osler Library, Montreal)

were phenomena capable of exerting only the feeblest forces and could not be detected except on the most delicate apparatus. Had they been neglected on the ground that the investigation of them promised no immediate result, we should now be ignorant of the most important and most interesting of the limits between the various forces of nature."

With the effect of this work on electrical science we are not concerned in this book. As a personal note it is pleasant to remember that the lovely Lucia helped her husband with his research. After her untimely death he sank into a melancholy. His work *De viribus electricitatis in motu muscularis* was published in 1791. He died, overwhelmed by his domestic sorrows, by his scientific controversies, and by political differences with the Cisalpine Republic, in 1798.

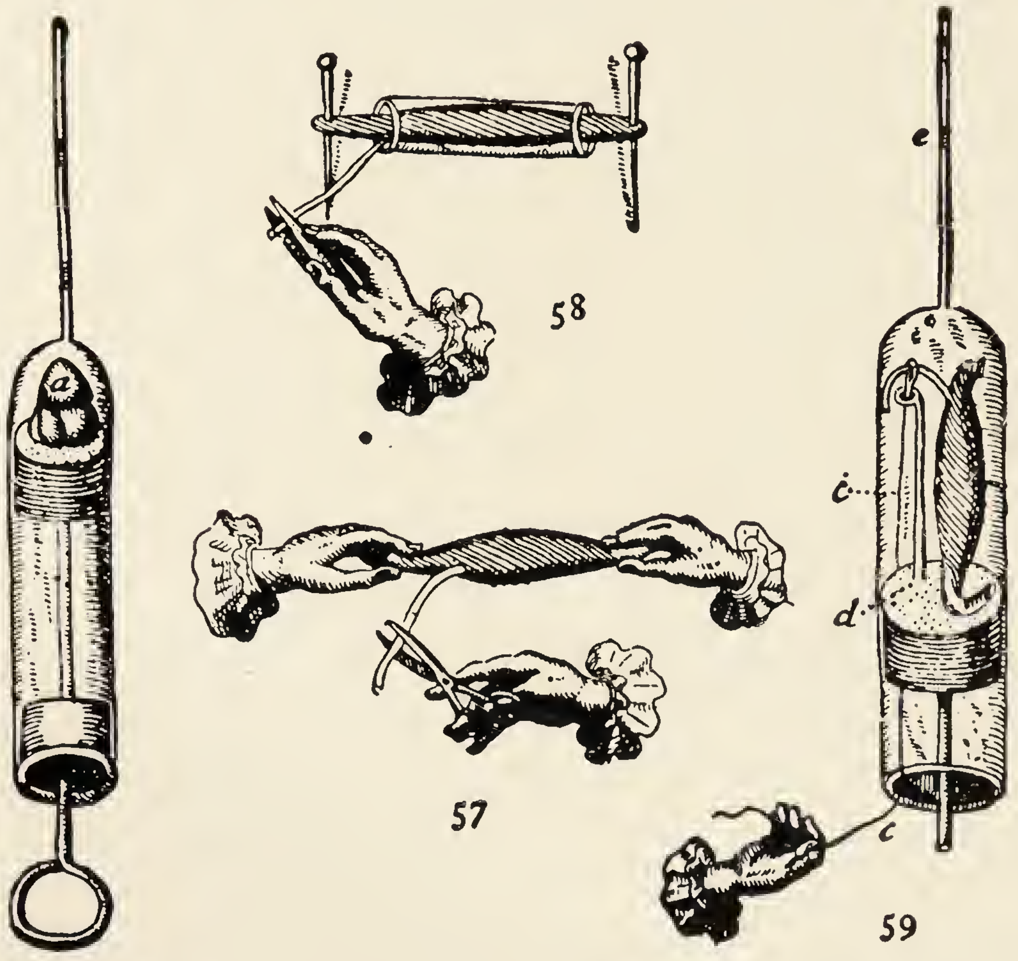
What does concern us here is the emphasis Galvani's work gave to one of the major problems of physiology — the relation of muscle to nerve, the nature of nervous impulses, the difference between sensory and motor impulses and reflex action.

The fact that the nerves end in muscles gave the first clue to the unravelling of the nature of the nervous system.

The mechanics of the muscles were studied in 1680 by an Italian, Borelli, who had been a pupil of Galileo's. Inspired by the mathematical atmosphere of his day, by the philosophic ideas of Descartes, and by the laws of motion which were being announced, Borelli conceived the idea of reducing the human body to the level of a machine. He showed the parallel between muscular action and the action of levers and pulleys. In this his influence was sound, although he committed himself to the erroneous doctrine that muscles received some sort of a fluid through the nerves, which caused them to contract. As did William Croone in a treatise published in 1664. All the early theories supposed the nerves carried fluid from the brain as the vessels carried fluid from the heart.

That same person we saw working with his microscope — Jan Swammerdam, the son of an apothecary in Amsterdam, was brought up amid his father's collection of animal specimens. Among other experiments, he isolated a muscle with the nerve hanging from it. He found that when he pinched the nerve with forceps, the muscle contracted. Hence something goes to the muscle by way of the nerve. But it is not a fluid, Swammerdam showed, because the muscle does not increase in bulk when it contracts — that is, no substance flows into it by way of the nerve.

The dominating figure in physiology during the eighteenth century was a Swiss, Albrecht von Haller. He is particularly associated with the idea of irritability. Irritability, the particular property of muscle, he said, was also the keynote of life. A muscle fibre shortens under stimulus, then lengthens to its previous size. This, said Haller, is irritability which belongs to the heart, the intestines, and other organs — its distinctive feature is that a small stimulus will produce a motion wholly out of proportion to its strength.



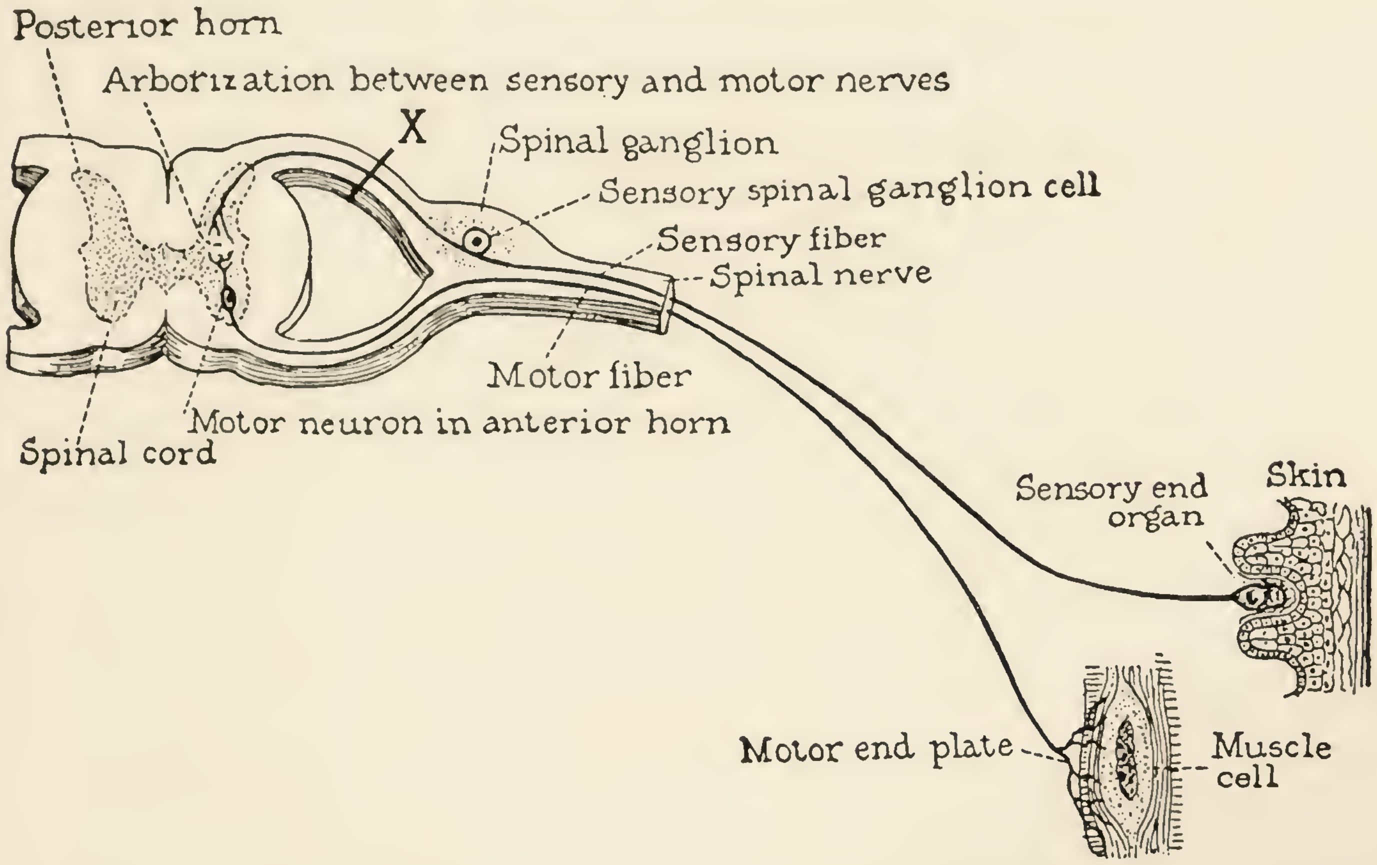
Swammerdam's experiments to illustrate the contraction of muscles when the nerves are stimulated.

Haller showed that all nerves were gathered together in the brain, and then he made a most important distinction. He said there are two kinds of nerve action or impulses — sensation and motion.

Were the nerves of sensation separate from the nerves of motion? The question went unanswered for a long time. Then, in 1811, Charles Bell, a Scotchman who had come up to London to make his fortune, published his account of some experiments he had made on the nerve roots emerging from the spinal cord. There are two sets of nerves which arise on each side of the spinal cord — one coming out from behind, one from the front of the cord. Bell decided to cut the posterior set of

these in an animal. "On laying bare the roots of the spinal nerves," he wrote, "I found that I could cut across the posterior portion of the spinal marrow without convulsing the muscles of the back, but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed."

This should have been plain enough, but Bell missed the significance of his own discovery, and it was not until Magendie, in 1822, reperformed his experiments that the clear distinction between sensory and



The reflex arc in the spinal cord. Bell, and afterwards Magendie, cut the posterior root at the point X. This destroyed sensation only: they found the animal could still make voluntary motions. (Figure from the author's book: The Human Body)

motor nerves was made. The posterior spinal nerves carry only sensation; the anterior, only motor impulses.

Such was the state of knowledge of the nervous system when Marshall Hall came to London to set up practice:

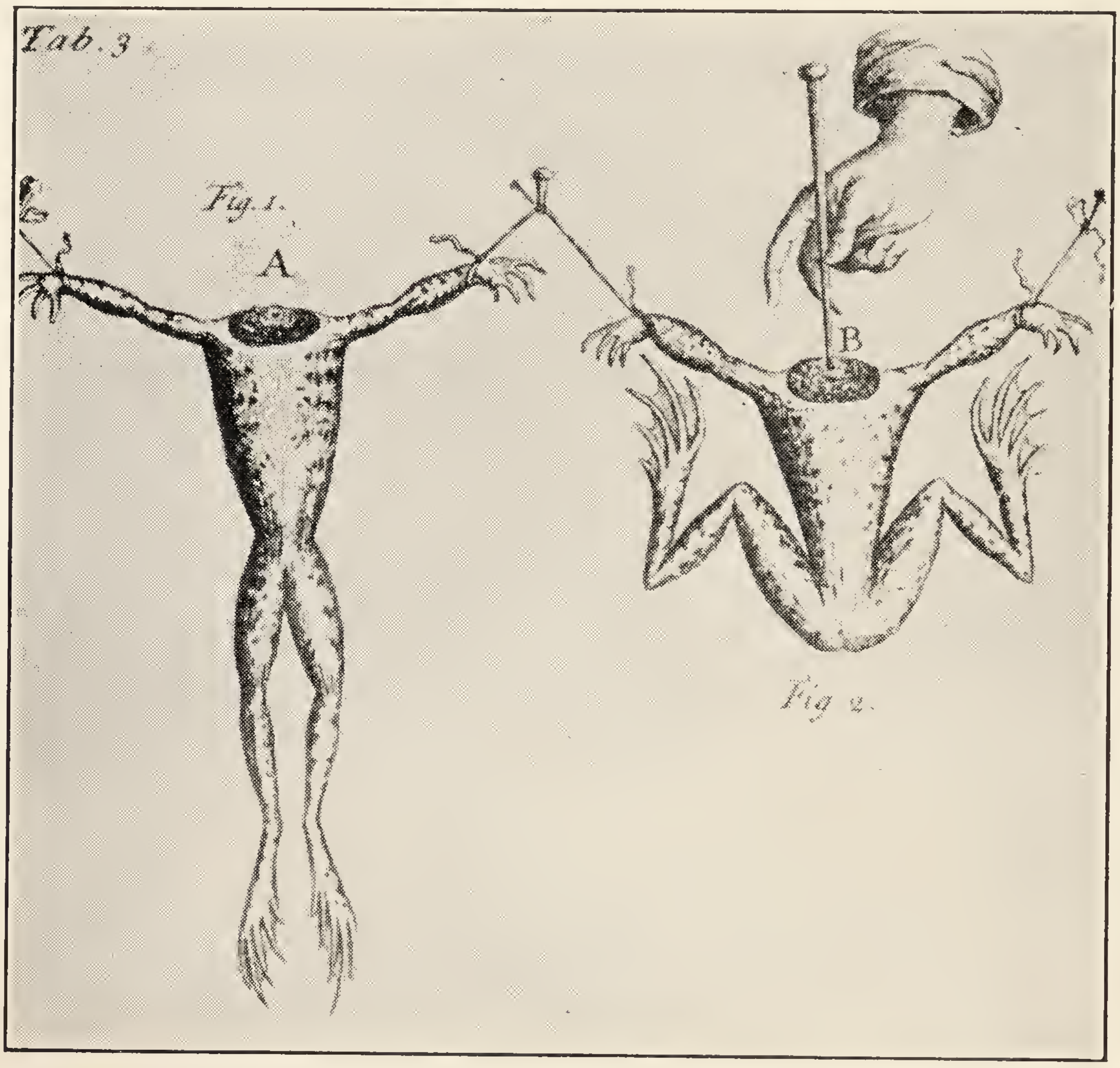
First, nerves arising from the spinal cord carried impulses from the spinal cord out to the muscles, which caused them to contract. Any stimulation of the nerve would start this contraction. Volition from the brain would do it. That is one of the functions of the mind. The mind is seated in the brain.

Second, nerves in the skin carry sensations to the spinal cord, and then they go up to the brain and register. That is how you know a needle is sticking in the skin.

"What does the spinal cord do?" Marshall Hall asked himself.

In spite of having one of the largest practices in London, he would neglect it to experiment. He was always messing round in his laboratory with newts and snakes and frogs, when he should have been out seeing his patients. His family and friends thought this was very foolish.

"What if you haven't got any brain?" he replied abstractedly to their remonstrances.



Alexander Stuart's experiments on the movements of muscles in a decapitated frog. He showed that the dead frog's muscles moved when a probe was passed into the spinal cord. He believed that the movements were due to pressing fluid through the nerves into the muscles. 1739.

"A frog! A frog!" he added hurriedly as he saw they mistook his meaning. "Suppose a frog hasn't got any brain! Its spinal cord still carries impulses."

Alexander Stuart had performed some experiments on frogs without a brain in 1739 (although Marshall Hall probably did not know of them). Stuart had decapitated a frog and hung its body up by the arms. When he pressed a probe against the exposed end of the spinal

cord, the frog's legs twitched. Stuart thought he pressed some fluid out of the cord through the nerves to the muscles.

Marshall Hall worked on decapitated newts and frogs. He found that if he irritated a spot on the skin of one of these headless creatures, the leg would move. His description is one of the great classics of scientific demonstration:

"You observe this living frog: its sentient and voluntary functions are obvious. I divide the spinal marrow, below the occiput, with these scissors: all is still. There is not a trace of spontaneous motion. The animal would remain in this very form and position, without change, until all signs of vitality were extinct. But now I pinch a toe with the forceps. You see how both posterior extremities are moved. All is now still again; there is no spontaneous motion, no sign of pain from the wound made in the neck. It is without sensibility — without volition; the power to remove remains — the will is extinct. I now pinch the integument. You observe the result — the immediate recurrence of excito-motory phenomena.

"I now destroy the whole spinal marrow with this probe. It is in vain that I pinch the toes; the animal, the limbs are motionless!

"Could the former excited motions be those of irritability? I will try the truth of this suggestion by seeing whether, now that the axis of the excito-motory system is destroyed, with its phenomena, the application of a slight galvanic shock will prove the subsistence of irritability. You see how instantaneously and forcibly the muscles are stimulated to contraction.

"Is not the proof, from these experiments, of the distinction between the motions of volition, of the excito-motory system, and of these from those of irritability perfectly and unequivocally complete?"

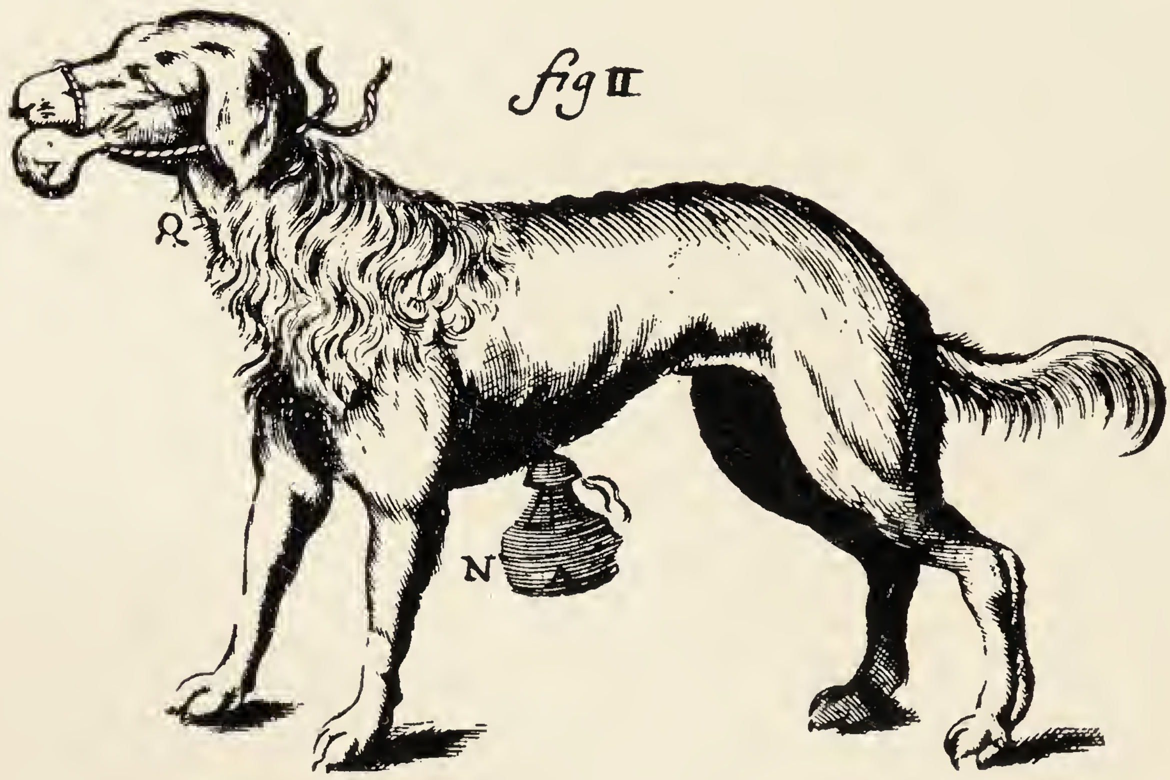
Reflex action is what Marshall Hall called it. It is tested when your doctor taps on the tendon just below your knee and watches the muscles of your leg jerk.

Marshall Hall's work was published in 1833.

3. *Digestion*

René Antoine Ferchault de Réaumur was a lawyer, the only member of that degrading profession who ever contributed anything to medicine.

He owned a pet hawk, a kite, and taking advantage of its habit of spitting up objects from its stomach which it could not digest, such as feathers, he placed meat inside of perforated metal tubes and made the bird swallow them. When they were regurgitated, Réaumur observed that the meat had been partially dissolved, but had no odour of putrefaction. Then he played a joke on the kite. He filled his tubes with small sponges, and when they were regurgitated, squeezed them out and thus obtained pure gastric juice, into which he placed pieces of meat and watched digestion outside the body. The kite finally died,



Early experiments on digestion. Dog with salivary and pancreatic fistulæ. De Graaf. 1671.

the first martyr on the altar of dyspepsia, and interrupted Réaumur's experiments. Réaumur's memoir *On the Digestion of Birds* was published in 1752.

Before Réaumur's time Regnier de Graaf, a Dutchman who deserves immortal remembrance from all members of what is sometimes chaffingly called " the weaker sex " because he described so fully the most fascinating of all their innards, the ovaries, and after whom the graafian follicles of those organs are named, had collected juice from the salivary glands and from the pancreas of dogs. These were obviously digestive fluids, but de Graaf did little more to elucidate their nature.

The whole subject of digestion was confused with several other phenomena — spontaneous changes which occurred in nature.

Here was food — it went into the body, and then what happened to it? Well, of course, it came out — in the form of fæces — but certainly it had suffered a change. And, as Sanctorius showed, the weight of the fæces was less than the weight of the food consumed. What had happened to the rest of it?

And here was wine — the grape juice lay quiet awhile and then began to boil, or ferment, and then was changed to wine. What had happened here?

And here was meat put out in the air — it stayed clean and fresh awhile, and then maggots appeared in it and it began to putrefy. What had happened here?

One idea was that the maggots had formed spontaneously out of the meat. Francesco Redi showed, however, that this was not true. If he put the meat in jars covered with gauze, the maggots would not appear in the meat, but would be found on top of the gauze. They were, as he proved, born from eggs laid by flies. There was no such thing as spontaneous generation, although country-folk still believe that horse-hairs put in the water-trough will turn into small snakes or eels.

The Abbé Lazaro Spallanzani showed that saliva would change bread outside the body, and that stomach juice would dissolve various kinds of food. Moreover, there was no putrefaction involved in the process. The food had no odour of putrefaction, and the dissolution occurred too rapidly for that.

But matters were so confused that Hunter could start a lecture in London with the words:

" Some Physiologists will have it that the Stomach is a Mill, others that it is a fermenting Vat, others again that it is a Stewpan; but in my View of the matter it is neither a Mill, a fermenting Vat nor a Stewpan — but a Stomach, gentlemen, a Stomach."

On June 6, 1822, at the little trading post of Mackinac, situated in the midst of some of the most beautiful country in the world, at the head of Lake Michigan, a young French-Canadian named Alexis St. Martin got in the way of a musket which was accidentally discharged. He was about a yard from the muzzle of the gun, and the charge tore away the wall of his upper abdomen and the wall of the stomach. He was attended by a young U. S. Army surgeon, William Beaumont. To everyone's astonishment, for such wounds were almost invariably fatal at

that time, he recovered. But he retained until the day of his death, sixty years later, an opening from the surface of his body directly into his stomach.

Dr. William Beaumont used this fact to undertake some studies on the nature of digestion and the properties of the gastric juice. He could see the inside of St. Martin's stomach. He could watch its movements. He could place food inside it and study the changes which occurred on the part of the food as well as the stomach wall. He showed that the gastric juice is poured out only when food is in the stomach, that the stomach digests only certain kinds of foods, and that the gastric juice contains hydrochloric acid and some other substance, to Beaumont vague, but later identified by Schwann as pepsin.

This work was quite as fundamental in its way for digestion as Priestley's and Lavoisier's work was for respiration. It set men's feet on the right path and opened the way for all subsequent research on the subject. The investigation of the action of the various digestive juices of the pancreas was carried to completion by Claude Bernard between 1849 and 1856, that of the salivary glands by Cohnheim in 1863. The movements of the stomach and intestines (associated with the names and dates of Ludwig 1861, Bayliss and Starling 1899, and Cannon 1902) have been the main lines of study since Beaumont's time and were suggested by his work. When it is remembered that his work was carried on in a remote fur trading post in the wilderness, far from any laboratories, and later under conditions of the greatest inconvenience and hardship, such as, for instance, transporting Beaumont's by no means docile experimental animal and patient two thousand miles across the wilderness to Plattsburg Barracks, New York, one cannot help feeling proud of this accomplishment of an American army medical officer.

4. *A Perpetual Curate and a Perpetual Problem*

The perpetual curate of Teddington from 1709 until 1761 was a very queer sort of parson, according to modern standards. He was certainly a very much better sort of parson, by any standards, than the majority of his fellow-divines in the eighteenth century. Their habit after they had acquired their livings was to turn over their parochial duties to some drab student who had taken orders. They gave the poor students starvation wages and devoted such of their time as they could spare

from the neglect of their duties to fox-hunting, county society, and accumulating cellars of port.

The Reverend Stephen Hales, in contrast to them, was faithful personally to his ecclesiastical duties.

But it would challenge our ideas of clerical propriety to see the village curate spending all of his week-days tying mares on their backs and cutting holes in their femoral arteries in order to see how high blood would rise in a tube which he immediately inserted; tinkering

Stephen Hales. He "discovered" blood-pressure.

with windmill ventilators; tying glass tubes around the stems of vines; scribbling his hourly observations of the barometer.

Perhaps his advocacy of temperance and his championship of the Gin Act of 1736, which put a high tax on spirituous liquors, would seem more appropriate. As would his interest in the success of the American colony of Georgia.

Gilbert White, the natural historian of Selborne, gives a lively picture of the "good old man" pottering about his parish; looking inside ladies' tea-kettles to observe how far they were encrusted with stone; teaching housewives to place an inverted tea-cup at the bottom of their pies and tarts to prevent the syrup from boiling over and to preserve the juice; painting white with his own hands, paint-pot before him, the tops of the foot-path posts that his neighbours might not be injured by running against them in the dark; directing air holes to be left in the out-walls of ground rooms to prevent the rotting of floors and joists; advising watermen at the ferry how they might best preserve and keep sound the bottoms and floors of their boats. And all of this, *mirabile dictu,* oh, happy curate, with such humility that he offended no one!

His last experiment was designed to prove that fish need air.

When he died, he had advanced biological science, according to his latest biographer, by his work on the circulation of the blood, particularly blood-pressure, the flow of sap in plants, the chemistry of respiration, and the growth of bone.

Blood-pressure! Gentle reader, if you have lived to adult life in the twentieth century, you must have heard of that. Somebody in your circle of acquaintances must be either proud or ashamed of his blood-pressure. Yours must be either too high or too low or just right. Gaze reverently, then, on the countenance of the perpetual curate of Teddington, the Reverend Stephen Hales, who invented the blame thing.

The Reverend Stephen, of course, had none of our modern instruments for measuring this pressure. He used the direct method — actually observing how high a column of blood would rise in a tube tied into the blood-vessel of an animal.

The first blood-pressure observations were made in 1710. Afterwards Hales experimented on "two horses and a fallow Doe." His first experiment on horses he records thus:

"In December I caused a mare to be tied down alive on her back; she was fourteen hands high, and about fourteen years of age, had a Fistula on her Withers, was neither very lean, nor yet lusty. Having laid open the left crural Artery about three inches from her belly, I inserted into it a brass Pipe, whose bore was one-sixth of an inch in diameter; and to that, by means of another brass Pipe which was fitly adapted to it, I fixed a glass Tube of nearly the same diameter, which was nine feet in Length. Then untying the Ligature on the Artery,

the blood rose in the Tube eight feet three inches perpendicular above the level of the left Ventricle of the Heart."

Following Hales's work the next advance in the study of blood-pressure was the description by Jean Louis Marie Poiseuille, in his graduating dissertation in medicine in 1828, of a hæmodynamometer. This instrument measures the pressure by direct insertion of a cannula into the blood-vessel, just as Hales's did, but it substituted a mercury column for the column of blood. Twenty years later, in 1847, Carl Ludwig added a float on the top of the mercury column and caused it to write on a recording cylinder, thus, as Stirling says, giving us at one coup "the kymograph or wave writer, and the application of the graphic method to physiology."

These measurements were all made on animals. The first record of the blood-pressure in man was made in 1856 by Faivre, who did as Stephen Hales did on his mare — he inserted a tube in the femoral artery of a man during an operation for amputation of the leg, but instead of measuring the height of the column of blood, he read the pressure as recorded on a column of mercury — it was 120 millimetres, the standard we still use as "normal" for the systolic pressure.

Vierordt and Marey about the same time used methods which did not necessitate the exposure of an artery. They were cumbersome, however. Marey's instrument required that the whole arm be immersed in water.

In 1896 Riva-Rocci demonstrated the instrument with the cuff encircling the arm connected with the mercury manometer, which remains, with a few minor improvements, as the standard instrument of today, upon which the glazed eyes of millions of candidates for life insurance have been fixed.

By these researches physiology had by the middle of the nineteenth century established many of its fundamental conceptions.

Let us summarize what was known: First, the function of circulation — that in animal bodies the blood is propelled by the heart to all parts. Second, the function of respiration — that in flowing through the lungs blood picks up oxygen from the air — the substance necessary to all life processes — and gives off the waste product carbon dioxide. Third, the function of the digestive system — that food goes through definite chemical changes, to prepare it for utilization by the tissues. Fourth, the nature of muscular contraction and the relation of nerves to muscles.

Fifth, something of the division of functions of the nervous system. Sixth, the function of excretion — that urine is formed in the kidneys, extracted by them from the blood. Seventh, something of the dynamics of the circulatory system. Thus the functions of most bodily organs were allocated.

PART V

A NEW IDEA IN THE WORLD —PREVENTION

In the middle of the rational eighteenth century thinking men had entirely abandoned the old idea that disease was a process different from any other process of nature. It was not sent by angry gods. It was not a punishment or a chastening. It could be studied just as water running downhill could be studied.

It is perfectly natural. But then came the staggering thought: "Is it inevitable?"

This is, indeed, one of the most revolutionary ideas which ever have been proposed. That the course of nature could be controlled by this puny instrument — man. That the great calamities — plagues, epidemics — to which man had always submitted as a part of fate, could be prevented.

To the story of how such ideas were formulated we now turn.

CHAPTER XIII

PREVENTING PLAGUE AND PESTILENCE

Smallpox was the first contagious disease which man found he could prevent. The narrative of the facts is relatively simple.

The first method used was inoculation — the introduction of diseased matter from a human smallpox patient into the body of the person to be protected. In most countries of the Orient this was done for many centuries before it was introduced into Europe. Chinese, Indian, and Turkish methods have all been described by travellers during the sixteenth to eighteenth centuries.

Inoculation was introduced into Europe from Turkey by Lady Mary Wortley Montagu in 1718 and practised until the introduction of vaccination. The difference between inoculation and vaccination is that in vaccination the diseased matter is taken from the cow. In the cow a disease called " cowpox " occurs. Whether it is identical with human smallpox is not known, but the introduction of cowpox matter under the human skin produces protection against human smallpox.

The advantages of vaccination over inoculation are that it gives equal protection without the danger of producing so severe a reaction; that the vaccine can be produced in unlimited quantities under the best sanitary conditions; and that it is possible to determine the possibility of a successful " take " more accurately.

These bare facts, however, are made vivid when the personalities associated with the discoveries are introduced. To attempt a portrayal of them shall be my task in the present chapter.

1. *The Dear Little Boy*

In September 1765 Mr. Samuel Sharpe, an Englishman then resident in Venice, heard that a fellow-countryman of a distinguished family, who had completed a long journey in the Orient, was in the Quarantine of that port. Animated by perfectly natural emotions — curiosity and snobbery (for his brother Briton was rich) — he visited the traveller and wrote this account of his appearance:

"His beard reached down to his breast, being of two years and a half's growth; and the dress of his head was Armenian. He was in the most enthusiastic raptures with Arabia and the Arabs. His bed was the ground, his food rice, his beverage water, his luxury a pipe and coffee. His purpose was to return once more amongst that virtuous people."

This convert to the ways and religion of the East was Edward Wortley Montagu, Jr., son of the richest man in England, and of that Lady Mary Wortley Montagu whose letters were considered the most elegant of her time. He is described in one of these letters as "her dear little son."

When, in 1716, Mr. Montagu, Senior, was appointed Ambassador to Turkey, his wife and this son accompanied him on that dangerous journey. While in Turkey, Lady Mary observed the Oriental practice of inoculation against smallpox. She described it thus:

"Apropos of distempers, I am going to tell you a thing that will make you wish yourself here. The smallpox, so fatal, and so general amongst us, is here entirely harmless, by the invention of ingrafting, which is the term they give it. There is a set of old women who make it their business to perform the operation, every autumn, in the month of September, when the great heat is abated. People send to one another to know if any of their family has a mind to have the smallpox: they make parties for this purpose, and when they are met (commonly fifteen or sixteen together) the old woman comes with a nutshell full of the matter of the best sort of smallpox, and asks what veins you please to have opened. She immediately rips open that you offer to her, with a large needle (which gives you no more pain than a common scratch) and puts into the vein as much matter as can lie upon the head of her needle, and after that, binds up the little wound with a hollow bit of shell; and in this manner opens four or five veins."

"There is no example of anyone who has died of it," she adds, "and you may believe I am very well satisfied of the safety of the experiment since I intend to try it on my dear little son." The boy was inoculated in March 1717. Something else must have been ingrafted into young Edward Montagu along with the smallpox — some strong nostalgic

Lady Mary Wortley Montagu in a Turkish costume.

poison of the East entered his blood — because for ever after his face turned towards that teeming, inscrutable country against whose dangers he had been so early protected.

One often wonders what happens in after life to the dear little sons of doting, clever mothers and rich, stern fathers. Proverbially, of course, they are likely to be a source of concern to their parents. To

say that Edward Wortley Montagu, Jr., was a striking proof of this proverb would be a gross understatement. His life was the apogee of all performances in that line.

He began by running away from home, three times, twice to sea (on the last occasion being identified by the inoculation scars on his arm); by contracting a low marriage (with a laundress some years his senior); and by squandering a fortune. But these were only the early examples of a prentice hand. The ease with which he accomplished these elementary tests in the art of being a spoiled child assured him of his vocation and he became the supreme genius of all time.

He sat for Parliament: or, rather, one must escape so conventional a phrase in speaking of him — he was elected to Parliament. Whether he ever sat is questionable. He may have walked round a little bit, but his record is conspicuous mostly for absenteeism. A part of his first term he spent in a French prison, accused of cheating at cards. From 1754 to 1768 he represented Bossiney in Cornwall, but it may be assumed he was not very assiduous, because in 1762 he left England, never to return. He published an octavo on *The Rise and Fall of the Antient Republicks,* which his literary mother considered not the least of his atrocities. During his travels on the Continent he, for a time, indulged the habit of dressing like a clergyman — or, rather, like clergymen, for in Rome he was an abbé, in Paris a priest, in Hamburg a Lutheran divine, and in Switzerland an Anglican bishop.

When his father died, he found himself in the novel position of being in funds, and made preparations for a scientific expedition to the East. As an indication of the earnestness of his purpose, he purchased 49 reading-glasses, 32 telescopes, and 145 pairs of spectacles.

He was at the end of this expedition when Mr. Sharpe called upon him in Venice. One of his adventures is sufficiently salty to deserve a detour in this narrative. The confession may as well be made. Mr. Edward Wortley Montagu, Jr., is my favourite character in fiction.

Despite the enthusiasm about his circumstances which he exhibited to Mr. Sharpe, they were such as might trouble a less exalted spirit. Three years before, he had stopped at Alexandria, had become acquainted with the Danish Consul there, Herr Feroe, and had fallen in love with Feroe's wife. The confidential nature of his position in the household did not prevent him from declaring his passion. Although the lady confessed that her affections had been touched, her virtue was

proof against final surrender. Not to be thwarted by so intangible a thing as virtue, Mr. Montagu devised a scheme. He persuaded Herr Feroe to make a trip to Holland in order to arrange for a loan from Mr. Montagu's bankers.

When the husband had been gone a short time, Mr. Montagu showed Frau Feroe a letter from Holland which declared that her husband

Edward Wortley Montagu, Jr., in Eastern costume.

had died suddenly. Mr. Montagu then proposed marriage. But even under these conditions the lady had qualms. She averred that she was a Roman Catholic, had once married a Protestant, and would not do so again. Nothing could shake her lover's persistency, however, and he expressed his willingness to be received into the Church of Rome. He

was so received, and, upon this proof of the bridegroom's sincerity, they were sealed in matrimony.

Remember that the bridegroom already had a wife in England — the laundress, who stubbornly refused to commit adultery so that the Montagus could procure a divorce, a circumstance which enraged them, and who lived in full enjoyment of her health, her marriage lines, and her title of Countess Montagu.

The newly married pair set out on a honeymoon in the Arabian desert on camels, both garbed in Eastern costume. On this expedition Mr. Montagu determined the exact spot in the Red Sea where the Children of Israel crossed over, made access to the very rock on which Moses stood on Sinai, and copied the inscriptions on the Written Mountains, all of which lore he faithfully communicated to the Royal Society.

Meanwhile Herr Feroe, the announcement of whose death seems to have come under the heading of propaganda, had, in far-off Holland, in turn, received the news of his wife's death and, as a matter of confirmation, a bundle of her clothes.

The letter which Edward Montagu had shown Frau Feroe announcing her husband's death, as well as the one which was sent to Herr Feroe announcing his wife's death, were both fictions — examples of the " dear little boy's " ingenuity.

When Herr Feroe disconsolately returned to his post in Alexandria, he was acquainted with the real facts.

To the apparent surprise of the contemporary diarists, he lost his temper. He determined to capture the runaway pair and proceeded to Smyrna, where he was placidly informed by the priest who had married him that his marriage had never been valid because he had always been a Protestant. This further enraged him, and he hurried to Constantinople, where he put his case before the British Consul, the voluminous Mr. Greville. Mr. Greville was " alarmed at the consequences," which he predicted to be a loss of British prestige in the Near East, an emotion which seems constantly to animate Englishmen at the spectacle of love-affairs among their fellow-countrymen.

A decree of incarceration was obtained against Mr. Edward Wortley Montagu, Jr., who, like the Duke of Plaza Toro, " hesitated not," but left the Countess Frau Feroe Montagu in a convent on Mount Lebanon, promised to return for her in a short time (a promise which he did not keep), and made his way to Venice.

It was in these circumstances that Mr. Sharpe found him so placid. Mr. Montagu stayed in Italy several years and while there was painted by Romney. His marriage to Frau Feroe was finally held to be legal by the courts on the grounds of his espousal of Frau Feroe's religion, but in the meantime he not only had cooled towards the lady, but had abandoned Rome to embrace Mohammedanism and had set out on the pilgrimage to Mecca. Some years later he appeared in Venice again, with a son who was "very near black," and several wives in the offing, and, it is related by the Duke of Hamilton, defended polygamy and concubinage, seated on a cushion on the floor, his legs crossed Turkish fashion.

In later life he wrote a waspish, but somewhat wordy autobiography which begins with the sneer: "My mother was a wit."

It is unfortunate that so staunch a supporter of the efficacy of vaccination as I am, should be compelled to exhibit what might be considered as the deleterious results of inoculation on its first European subject. Even stranger effects were ascribed to it in time. But it is worth noting in the interests of science that in spite of his long sojourns and wanderings in the plague-infested Orient, Mr. Montagu never suffered an attack of the smallpox.

2. *Inoculation*

It is appropriate that the history of the prevention of smallpox should be introduced by this bizarre figure. The whole history of vaccination is so incredible that worldlings, such as Bernard Shaw, refuse to be taken in by it. It is a drama of crowded incidents peopled by a cast as brilliant as a pack of cards. Starting with the fascinating Lady Mary and her scapegrace son, there is an empress, Catherine of Russia, and her lovers, their Majesties of England and of France, a dairymaid, an honest yeoman, a medical baron, and one of the true geniuses in medical history, Edward Jenner.

It was in 1717 that Edward Montagu, Jr., was inoculated at Pera. The Montagus returned to England in June 1718. Lady Mary immediately set about advocating inoculation. She was a managing kind of woman and usually got her way. The physician attached to the Montagus' mission to the Porte, Dr. Maitland, began to inoculate under her patronage, and the custom grew very rapidly. In spite of the opposi-

tion of the clergy, who considered that smallpox was the special providence of God, the practice gained the support of many influential people, notably Dr. Richard Mead. Mead was the foremost practitioner of the day, physician to His Majesty, and, to judge by his books, a shrewd observer. His advocacy would have been a great help to any cause.

The idea of preventing a contagious disease by injecting some of its own poison into the body was entirely new and naturally inspired considerable fear. Early in the day, therefore, when only a few persons had submitted to the operation and people were reluctant to try it themselves, Lady Mary bethought herself of a brilliant scheme. There were seven criminals in Newgate under sentence of death. Lady Mary persuaded the court and the authorities to offer them the chance of pardon if they would submit to inoculation in order to determine its dangers. Naturally they all accepted, and stumbled out of the shadow of the gallows into the hands of Dr. Maitland, Sir Hans Sloane, and Dr. Mead. Six were inoculated on the 9th of August 1721, in the way described by Lady Mary, from Constantinople, and one by the Chinese method, which was to place dried pock scales in the nostrils. All of them contracted the disease in a mild form. The one on whom the Chinese method was practised suffered the most, from severe pains in his head.

From that time on, inoculation was practised very widely, not only in England, but in France and other Continental countries. There was never a time when control of a disease was more needed. Smallpox in Europe was like a continuous state of the influenza epidemic which we experienced in 1918. It was as deadly and as general. Most of my readers will remember the shadows of those fearful days. In 1721, when the Newgate experiment was tried, there were 2,375 deaths from smallpox in London, with a population of about 600,000.

Compare the deaths from smallpox after vaccination became compulsory. For England over a period of four years (1886–9, inclusive) 16 persons died of smallpox per year per million of population. In England both the activity of anti-vaccination propaganda and the laxness of official insistence in the face of such propaganda have made the "compulsory" part a dead letter. In Germany, where the compulsion is well enforced, the deaths from smallpox in those years was 3 per million of population per year. Compare that with the figures just cited

for 1721 in London, where about 4,000 per year per million of population died.

Nor was death the only terror of the pestilence. The early records of the London Asylum for the Indigent Blind show that nearly two-thirds of the inmates had lost their sight from the ravages of smallpox.

One would think that any method which had the least promise of success in warding off such a horror would be eagerly embraced. Such is the perverseness of human nature, however, that there developed as much fear of the cure as of the disease.

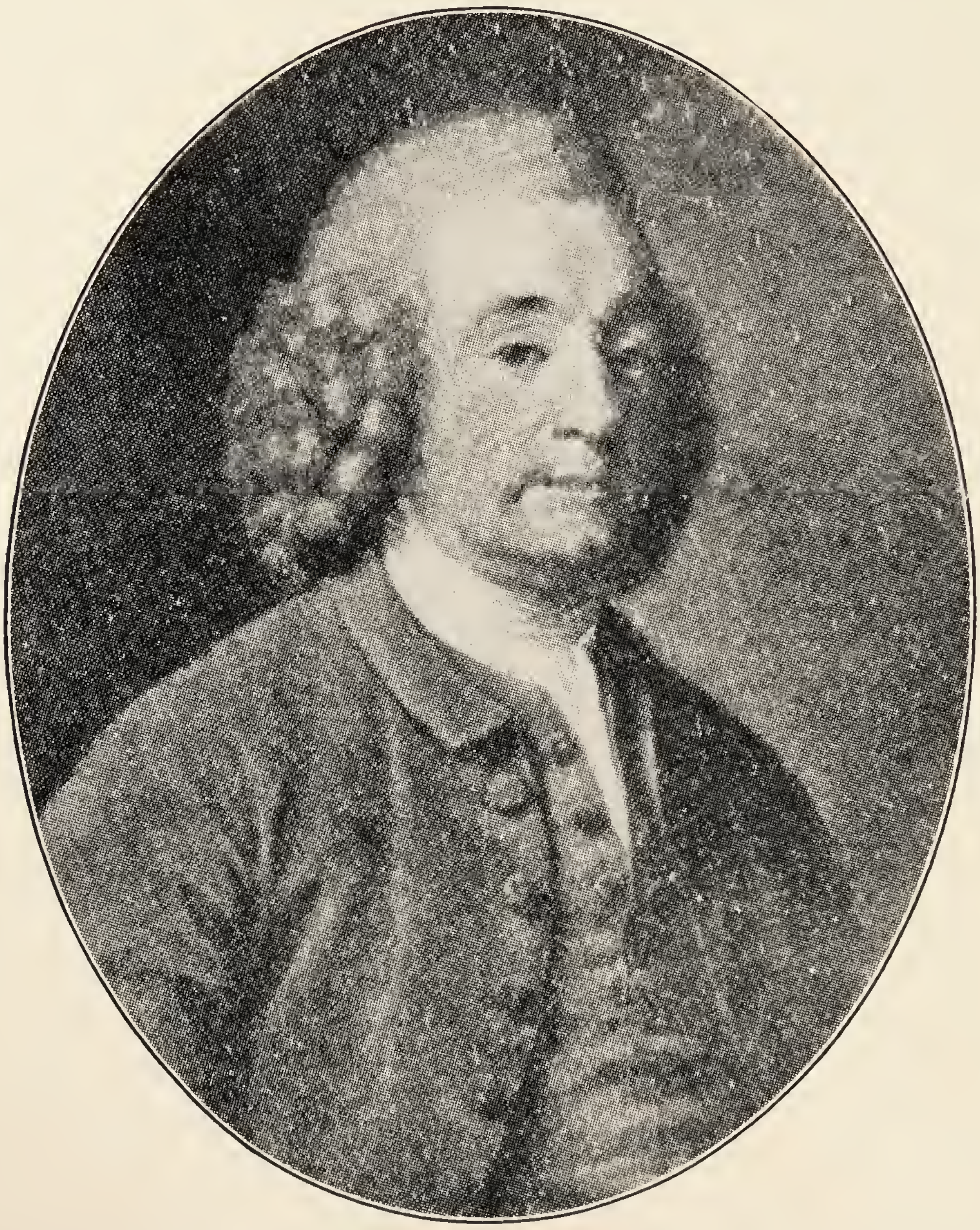
The reception of inoculation in America well illustrates the general feeling that its advocates had to combat. In 1721 smallpox visited Boston with great severity. The Reverend Cotton Mather had copied the accounts of inoculation sent him by his learned friends from abroad and had turned them over to the practitioners of Boston. Dr. Zabdiel Boylston inoculated 244 persons, of whom 6 died. This resulted in a meeting of His Majesty's Justices of the Peace and the Selectmen in the Town Hall, where resolutions "concerning Inoculating the Smallpox" were passed, showing "that it has proved the death of many persons," that "the natural tendency of infusing such malignant filth in the Mass of Blood, is to corrupt and putrefy it," and "that continuing the operation among us is likely to prove of most dangerous Consequences."

But in spite of all opposition inoculation continued to be practised. Many famous inoculators made their reputations. Perhaps the best-known in England was Thomas Dimsdale. He popularized a new technique for inoculation originally devised by a Mr. Robert Sutton, who practised medicine and pharmacy in Suffolk. This technique was to bring the person to be inoculated into the room with a patient sick with the smallpox and to remove some matter from one of the pocks and insert it with a lancet under the skin of the candidate for inoculation.

The method, as can be seen, is much like a modern vaccination except that pus from an actual patient with smallpox was used instead of the pus from a lesion on the udder of a cow suffering from cowpox.

Dimsdale's most famous act was his expedition to Russia at the request of the Empress, Catherine the Great, in order to introduce the practice of inoculation among her subjects. I have before me the book he wrote on his return. The date of his journey was 1768. Catherine was then

thirty-nine years old. Her son, the Grand Duke, afterwards the Tsar Paul, was fourteen. Her husband had been deposed and conveniently had died, probably not entirely of natural causes, eight years before. She was at the zenith of her prosperity and powers. Her favourite adviser and lover was Gregory Orlov. His gigantic figure, blazing with jewels, swaggered ever at her side. In his demeanour, so tradition and Macaulay aver, the ferocity of the Scythian might be discerned through



Dr. Thomas Dimsdale (afterwards Baron Dimsdale). He inoculated the Empress Catherine the Great.

the thin varnish of French politeness. He had borne the chief part in the revolution to which she owed her throne. The courtiers whispered that his huge hands, glittering with diamond rings, had given the last squeeze to the windpipe of the husband of his august mistress.

Into the atmosphere of this barbaric court the dainty little English doctor entered, with a mien of bland and unworldly innocence. To read his pages you would think he had been summoned to a pink tea. No

expression is too extravagant to record his opinion of the graciousness and intelligence and charm of his royal patron.

Catherine had personal as well as political reasons to dread the smallpox. Her husband's face, already insipid and ugly, had been badly pitted by pock-marks. In a strong countenance such scars add an element of dignity. But upon his perverted and hideous features they only heightened the impression of depravity. On that last occasion when she ever saw him, when he leaned across the table in the presence of the court and spat out the word "Fool" at her, the candles lit up those pits as if they were the craters of some foul and loathsome region of the Styx. She left his presence, and two months later her plot to depose him was successful.

On the political side, Catherine was urged not only by the existence of smallpox among her people, but by the example of all enlightened European countries in taking up inoculation. In Germany Dr. Maitland had started it in 1724. In France it is said to have been performed in 1717, and six years later to have acquired quite a vogue. In Holland, Denmark, Sweden, Switzerland, Italy, and Spain it was performed with varying degrees of success. So enlightened a ruler as Catherine, pupil of Voltaire, would certainly be expected to make special efforts to give her people the benefit of this ultra-modern device. The more so as the epidemics of smallpox in Russia were particularly severe and threw the superstitious peasantry into a ferment of disquietude. About her the court spoke of the chance that her son, the Grand Duke, would die before he reached the throne because he had not yet had the smallpox.

Widespread as the interest in Dr. Dimsdale was, when he was actually on Russian soil there was a certain slowing up in the proceedings. Nobody wanted to be the first to try the experiment.

So deep was the general distrust that it is said that when the time came for the inoculation to be performed on the Empress, she had relays of post horses prepared from St. Petersburg to the extremity of her dominions to ensure the doctor's escape if a disastrous result ensued.

It must be said that in the face of this state of mind Catherine acquitted herself with great courage and credit. At their first interview the doctor inspired her with complete confidence. On his side, the impression was equally favourable. "She has a way of pleasing without appearing to have an art," he notes. "The propriety of her questions

relative to the practice and success of inoculation" also arrested his admiration. At their second interview she informed him that she had decided to be inoculated with as little delay as possible. But the poor fellow had been bombarded with warnings by Count Parrin, the Prime Minister, to the effect that "To your skill and integrity will probably be submitted no less than the precious lives of two of the greatest personages in Europe."

He therefore suggested to the Empress that she have some opportunity of observing the effects of the procedure on less exalted examples of the human race. She replied with great spirit: "My life is my own and I shall with the utmost cheerfulness and confidence rely on your care alone." Nevertheless he persuaded her of the propriety of his views.

Finally two military cadets either were ordered or volunteered to be the first victims. The result on their persons was successful, and on Sunday, October 12, 1768, the Empress was inoculated, went through a mild course of smallpox, with one pustule on the face and two on the wrist, and on October 28 returned to her usual activities; she "appeared at court, where she received the congratulations of the nobility and gentry who attended on this joyful occasion."

The Grand Duke was inoculated on November 1 and was recovered by November 22. His subsequent career was even more spectacular than that of Mr. Montagu. Indeed, the early experiments in this field do not furnish a particularly lively example of the beneficial effects of the practice. Paul's reign was a nightmare for his subjects, the frenzied mania of a madman. He was finally murdered in his bedroom in the St. Michael Palace in 1801 and his son, Alexander, reigned in his stead. But even the anti-vaccinationists have not held his aberrations to be due to the practice.

Dimsdale was made a Baron of the Empire, a Councillor of State, and appointed body-physician to the Empress. He was paid two thousand pounds for his expenses and presented with an honorarium of ten thousand pounds and an annuity of five hundred pounds. He spent some months in Russia inoculating many members of the nobility, including Gregory Orlov.

After Dimsdale returned to England, inoculation went forward in Russia at a rapid pace. But the size of the population — the magnitude of the public health problem involved — was too great for the authori-

ties. In 1771 a violent epidemic of smallpox broke out in Moscow. The people became suspicious of the Empress and her physicians and gathered at the statues of the Virgin to supplicate for aid. This massing of infected and uninfected persons about the shrines naturally spread the disease like wildfire. When the Bishop of Moscow, realizing this effect, had the most popular of the shrines, that of the Virgin at the Varvarsky Gate, removed and endeavoured to reason with his people, the mob invaded his palace, followed him to the lowest cellars, and tore him limb from limb in the darkness.

Under these circumstances Count Gregory Orlov was sent with a regiment to bring order to the city. The Count was not always distinguished by personal courage, but since he had been inoculated by Dimsdale, he appears to have believed thoroughly in his own immunity from smallpox. He therefore on this occasion bravely entered the infected city and in a short time calmed the terror-stricken people and brought the epidemic within reasonable limits. It is worth noting that although fully exposed at this time, the inoculation protected him.

Orlov's achievement was hailed with delight by the Empress. She struck a medal in his honour. But when a few years later a younger favourite, Vassilchikov, supplanted him, and Orlov, who was with his regiment, started to return to Petersburg to guard his interests, the Empress had him incarcerated in his own palace at Gatchina. She was not one to have her love-affairs spoiled during their first ardours by the presence of a former lover. There must have been a twinkle in her wicked and worldly old eyes as she explained in the note which accompanied the motherly gift of compotes she dispatched to Orlov by messenger that the action was taken out of solicitude: smallpox was in the south and she feared he might bring it in his person to Petersburg — he, who with her had been rendered immune by the English Baron's lancet.

3. *What Medicine Learned from a Dairymaid*

Inoculation, as we see, was never widely popular. It was at once too dangerous and too uncertain. Plain suppurative infections at the site of the inoculation were assumed to be "takes," and frequently such patients would later acquire smallpox, thus bringing discredit on the procedure. The early literature is acrimonious with such examples.

But science was slowly stumbling forward. Inoculation prepared the way for vaccination.

It had long been a tradition in the English country-side that a milkmaid could catch a pustular eruption on her hands from milking an infected cow, and that this eruption would protect her from smallpox.

As early as the time of Charles II there was some gossip as to the possibility of the disease known as cowpox being transmitted to human beings and giving rise to an indisposition which protected from smallpox. The Duchess of Cleveland, whose beauty and debauchery made her the mistress of the King and the scandal of Europe, was at one time rallied by a courtier who suggested that the smallpox might ravage her lovely countenance and the consequent disfigurement lose her her position. She replied that she could not get the smallpox because she had once had the cowpox.

The disease in the cow consists in the eruption of pustules on the nipple (udder). In horses the same inflammation appears on the heel, called "the grease."

The first man who ever deliberately tried to use these animal diseases to protect human beings from smallpox was a Dorsetshire farmer, Benjamin Jesty. He was a figure typically dear to the English heart, a blunt, honest, utterly unaffected yeoman, who must have been a good deal of a "card." In 1774 he took cowpox matter and introduced it under the skin on the arms of his wife and two of his sons. The sons had a mild "take," but Mrs. Jesty had a severe inflammation and apparently nearly lost her life. At least, her experience was so alarming that it prevented the country-side from continuing the practice, and thus probably prevented the introduction of vaccination at that time.

In later years Jenner seemed to believe that Jesty's account was trumped up to deprive him of the credit. The controversy was set at rest when the Jennerian Society of London invited Jesty to come up to London and appear before them and have his portrait painted as the "earliest inoculator for cowpox." This he did, bringing his son Robert, who had been one of his three patients. The society were "much amused at Jesty's appearance and manners. Before he left his country home, his family had tried to induce him to attire himself more fashionably for his visit to the metropolis, but without effect. 'I do not see,' said the bluff old farmer, 'why I should dress better in London than in the country,'

and so he appeared before the society in his usual dress, which was peculiarly old-fashioned. In order to prove their statement, Mr. Robert Jesty willingly consented to be inoculated for the smallpox and his father for the cowpox, but neither took effect.

" Mr. Jesty was presented with a pair of very handsome gold-mounted lancets, and his portrait was also taken by Mr. Sharpe; but he proved

Benjamin Jesty. He first performed vaccination.

an impatient sitter and could only be kept quiet by Mrs. Sharpe's playing to him on the piano."

Strictly speaking then, priority for the employment of vaccination against smallpox belongs to Jesty. But, as in other controversies on priority in medical discovery, the question must be settled by other considerations, and the real credit belongs to Edward Jenner. He not only arrived at the idea independently of Jesty, but by his influence and his

clear demonstration made its practice universal. And he devised the proof of its efficacy.

Edward Jenner (1749–1823) was a Gloucestershire man, the son of a clergyman, who received a good education and served an apprenticeship in medicine under John Hunter in London. He returned to Gloucestershire to practise and contracted a marriage regarded as substantial in the eyes of the world. Although he continued to enjoy the

Edward Jenner, M.D. From a painting by Northcote.

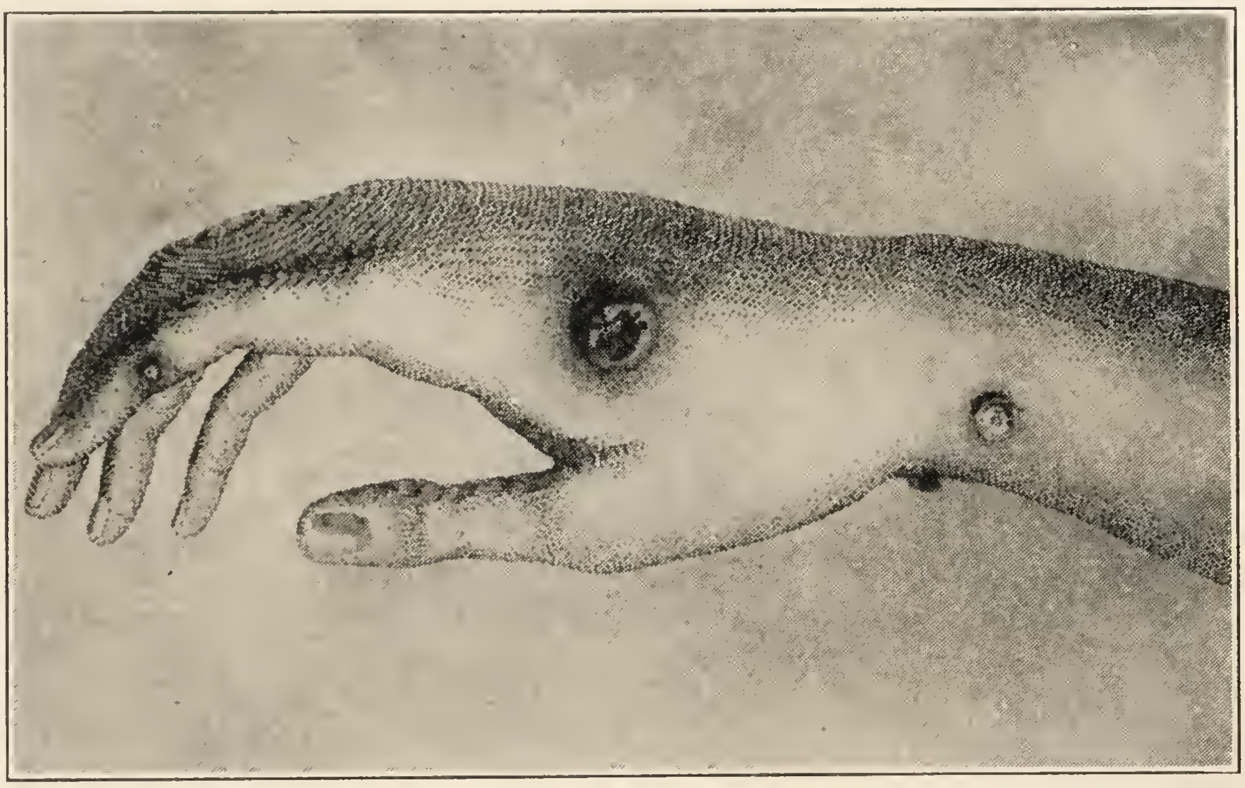
regard of John Hunter (samples of their correspondence are recorded in the chapter on Hunter) there was no indication during his early years that he was anything more than an average plodder. True, he wrote an ode "To a Tom-tit," but none of his poetical effusions would suggest that there was reserved for him so glorious a niche in the temple of fame.

Somewhere about 1782 Jenner was talking to a friend, Edward Gardner, as they were riding together along the Gloucestershire roads. Jen-

ner explained how he supposed smallpox originated: a farrier or farmhand treating the grease on the heel of a horse would then perhaps milk a cow, and some of the infectious matter clinging to his hands would communicate it to the cow. Then a dairymaid would milk the cow and pick up the cowpox on her hands, possibly even transmit it to other persons. He even suggested the chance that deliberate vaccination of all mankind might drive the plague from the face of the earth.

"Gardner," he said, finally, "I have entrusted a most important matter to you which I firmly believe will prove of essential benefit to the human race."

He talked it over with many friends, including his greatest benefactor, John Hunter. Hunter's advice is famous: "Don't think, try; be patient, be accurate."



The hand of Sarah Nelmes.

In May 1796 Jenner saw the hand of Sarah Nelmes. She was a dairymaid and had a pustulous eruption on her wrist and forefinger and base of the thumb which she had caught from an infected cow. On May 14, 1796 he took some matter from these pustules and inserted it into the arm of a boy, James Phipps, by means of two superficial incisions. On the seventh day James complained of an uneasiness in the armpit, had an eruption at the site of insertion, and finally recovered.

This was all very well, but was he protected from smallpox? Was the gossip of the country-side mere gossip or did it have any real foundation? Did cowpox protect from smallpox?

Such were the questions which confronted Jenner. And his hard scientific mind determined the way to put the subject to a final test. It is this final test that the anti-vaccinationists all seem to forget.

On July 1, 1796 Jenner inserted infectious matter from a pustule of a person who had smallpox under the skin of this same James Phipps.

Jenner's first vaccination. From the painting by Gaston Melingue. The boy Phipps is being vaccinated against smallpox with vaccine lymph taken from the hand of Sarah Nelmes, suffering from cowpox. She is binding her sores, and in the foreground her dairymaid paraphernalia may be seen. Jenner wields a historic lancet. The scene is Berkeley, England; the date May 14, 1796.

No disease followed. " Several months later the boy was again inoculated with variolous matter, but no sensible effect was produced on the constitution."

Here is Jenner's whole contribution to modern medicine in a nutshell. He proved a person could be rendered immune to a disease artificially by being given an attenuated form of the disease. Or a slightly different form — that is, after it has passed through an animal. Then, most valuable of all, he proved by exposing the individual who had been vaccinated to smallpox that the artificially produced immunity protects from the actual disease.

What happened after that simple experiment in the Gloucester dairy is now the affair of the world. Smallpox, which was continuously epi-

The progress of vaccination. An "anti" cartoon of 1800. The loathsome diseases derived from vaccination are represented in the triumphal car, drawn by a cow and a mule (animals from which the vaccinal matter is obtained). Astride them are physicians, one with a lancet used for making the vaccination incision in his hand. To the right the innocent little children, the victims of the practice, instinctively flee.

demic in Europe and America during all the period for which we have statistics up to 1800 — so frequent and universal among the population that a fugitive from justice would be advertised as not having pockmarks on his face to distinguish him from the rest of the world — is now a medical rarity. Students pass through four years of medical school and never see a case. In every country where vaccination and revaccination is compulsory and enforced, smallpox has practically disappeared. In such countries as England, where vaccination cannot be rigidly enforced, but where smallpox cases are strictly reported and quarantined, smallpox has always a respectable incidence.

This last fact gives the quietus to those opponents of vaccination who suppose that ordinary cleanliness and quarantine have been the cause of the disappearance of smallpox. General Leonard Wood may be quoted. In China, in 1898, two battalions of American soldiers, all vaccinated against smallpox and "in a fair state of discipline, were sent into a country infected with the most virulent type of smallpox, where the death rate was heavy and all sanitary conditions were against them, and although living for months in towns infected with the most malignant type of smallpox, to which they were constantly exposed, not a single case occurred in the regiment."

The ideas thus implanted in men's minds have germinated. Other infectious diseases are included in the preventable class. Typhoid fever is no more, largely because of typhoid vaccination. Diphtheria in ten years can be a thing of the past. Perhaps also scarlet fever. All those diseases to which every individual is potentially exposed and which are so fatal and so deforming can be produced in youth in the body in a mild form: for ever after that the body will be protected from their dangers.

This is the greatest single triumph of medicine. It has actually estopped the natural malignity of nature.

The idea of injecting serums into the body has always had opponents. Soft-minded, well-meaning folk who have a curious twist, a way of emphasizing all the logical points on the wrong side of the picture — the anti-vaccinationists, the anti-thises and thats — such people will always be among us. Their intentions are good, so we are assured: and of such are the pavements of hell.

CHAPTER XIV

WHAT MEDICINE LEARNED FROM A SAILOR

Venus was expected to perform a transit. The manœuvres of Venus always interest males. Astronomers were accordingly excited. Because the Venus who was going to transit was not the goddess, but the planet. And because of these facts the world learned how to prevent the human body from acquiring one of its most dangerous and loathsome diseases, scurvy.

Venus and scurvy seem somehow unrelated. The transit of Venus and the prevention of scurvy even more so. Their association is accomplished in the person of a forthright Yorkshireman named James Cook.

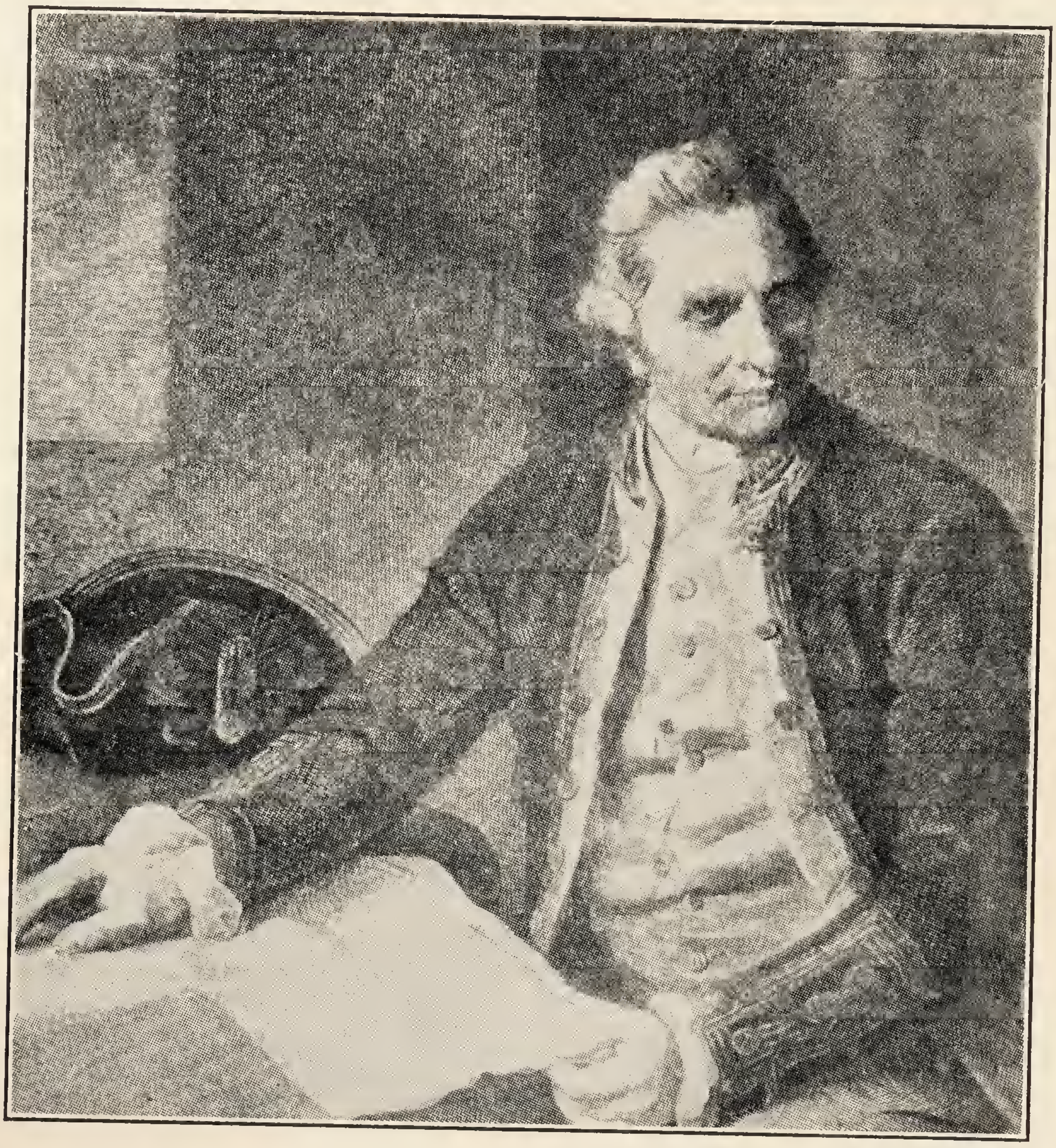
Captain James Cook was the greatest of the second generation of English navigators. The first generation comprises the Tudor seamen — the Cabots, Drake, Hawkins, Gilbert, Frobisher, and Cavendish. Cook's exploits came at a considerably later date. His first great voyage was completed in 1770.

From the standpoint of permanent advantage to the Empire, Cook's expeditions were probably more important than those of the older sailors. He was one of the first white shadows in the South Seas. For all practical purposes, he may be called the discoverer of Australia, and responsible for its annexation to the British Empire. He did definitely discover and annex New Zealand. He named the Sandwich Islands after his patron, Lord Sandwich, that gentleman who, struck suddenly with inspiration, invented one of the triumphs of gastronomy. Cook was an empire-builder extraordinary.

Books on travel to me are usually dull. I take no interest in them unless I have been in the countries described. But in looking up ma-

terial for this history I was perforce compelled to read the now neglected *Voyages of Captain Cook*. And I must record the delight and pleasure to be found in that fresh and astonishing narrative.

To be the first who ever burst into that far from silent sea! That was Cook's great experience. That sea where little tropical islands, hitherto unknown to any white man, suddenly appeared at his vessel's prow.



Captain James Cook.

Islands where strange birds of brilliant plumage — macaws and parrots and raridos — could be seen flying about the trees and among the vegetation growing in such profusion down to the water's edge. From these islands the natives would push out in their canoes to inspect the enormous sailed visitor to their shores — friendly, grinning natives, bearing baskets of fruits and branches of bananas.

The fascination of Cook's own account is the plain unvarnished way he records all these brand-new things. And the care and the detail! It

is like a little child's account of his first visit to the zoo. To us it is all an old story. We moderns, hardened worldlings that we are, have seen a kangaroo. But Cook had never had that thrill. He sees one in its native woods. "As I was walking this morning at a little distance from the ship, I saw myself one of the animals which has been so often described. It was of a light mouse colour." He "should have taken it for a wild dog, if instead of running it had not leapt." Modern travellers in the South Seas seem so sophisticated and so bored beside James Cook.

Plate of the kangaroo in Cook's Voyages.

James Cook ran away to sea when he was fourteen. At twenty-seven, having been at sea during the whole interval, he joined the Royal Navy. In 1768 the gossip about Venus began to be bruited about in the office of the Astronomer Royal, and Cook was appointed to conduct an expedition to observe the transit.

By *"the transit of Venus"* the astronomers meant that the planet would pass directly between the earth and the sun. This phenomenon afforded an opportunity of calculating the size and distance of the sun. According to the calculations of the astronomer, the point on the earth's surface where Venus could best be seen passing between earth and sun was in the Pacific Ocean almost midway across, off the coast of South

America, the best spot being considered Tahiti, one of the newly discovered group of the Society Islands.

To Tahiti then James Cook was instructed to go by way of the Atlantic Ocean, rounding the southern extremity of South America, Cape Horn, and with the scientific men furnished by the Royal Society to make the required observations. He was further instructed by the Admiralty to proceed across the Pacific Ocean, which was then little known. The Southern Continent was a sort of mythical land which was supposed to be somewhere in mid Pacific, balancing the Northern Continent. Cook was instructed to search for it and to chart all the lands he found.

It was a prospect to make the heart of a true sailor leap up. To sail an unknown sea, to discover a new continent, to risk hardship and danger. There was only one trouble — scurvy.

Few vessels in those days came into port without a dreadful death-rate among the crew from scurvy. Hawkins, the Elizabethan, said that in twenty years upon the sea he had known of ten thousand deaths in his crews from scurvy. Over one a day. The longer the voyage, the more cases of scurvy.

So as James Cook's mind travelled out over that waste of waters that was to be his path, when he remembered he would be at sea one, two, or possibly three years, it is no wonder his heart had qualms at the thought of the scurvy. For he had been at sea all his life and knew the scurvy at first hand. He knew, too, that the reason the Southern Pacific had never been charted was that " all those lost adventurers, his peers," who had tried it before him had had to give it up because their crews were so decimated by scurvy.

First a sailor's gums would begin to bleed. Then some of his teeth would fall out. The stench from his mouth would be horrible. Then great blotches would appear on the skin. The wrists and ankles would swell. A bloody diarrhœa set in. Parts of the flesh would rot out. Finally, exhausted, delirious, loathsome, the poor wretch would pay his debt to nature.

Lieutenant James Cook had a right to look serious when he considered the scurvy. But he thought he knew something about its cause. Cleanliness, that was his idea; cleanliness and fresh air. The living conditions of sailors were indeed dreadful then. They slept in the filthiest, darkest, and most crowded part of the ship. No attempt at ventila-

tion of their quarters was made. Vermin swarmed. The sailors' bedding was seldom aired. No regulation of their bathing was obligatory. All these matters James Cook set himself to remedy.

The question of food had frequently been under discussion also. The food on long voyages in those days did not tend, from the accounts, to appeal to epicures. " Beef badly salted and sometimes so rotten, that, before boiling it, it was necessary to tie it round with cords: biscuits mouldy and full of weevils and maggots: and pudding of salt, suet and flour." Cook knew this — in fact, wrote it — and he intended to do his best to remedy it by cleanliness in the kitchen. But we must remember that there was no refrigerator in those days — no way of manufacturing ice on a long voyage. Even the distillation of fresh water from sea water had been practised for only a few years — since James Lind, physician to the Haslar Naval Hospital, had introduced his hygienic reforms for seamen.

This same James Lind had written a *Treatise on Scurvy* in 1754. In it he wrote: " Experience sufficiently proves that as greens or vegetables with ripe fruits are the best remedies for it, so they prove the most effectual preservatives against it."

Cook knew this. In the famous paper he read after his return he discussed " the rob of oranges and lemons proposed by Lind for use at sea."

Indeed, even Lind himself was not the first to suggest this method of prevention. John Woodall, Surgeon General to the East India Company, wrote a book in 1617 called *The Surgeon's Mate,* in which he called attention to the value of lemon juice in preventing scurvy.

With resolutions, then, appropriate to his notions of the cause of scurvy — resolutions to carry out such measures as would prevent it — Cook prepared to execute his orders and to condition his ship for that voyage fraught with dangers, but of which by all odds the most deadly was the disease he knew so well. His vessel was the *Endeavour,* of 370 tons, which lay in the basin of Deptford Yard. From Deptford she sailed on July 30, 1768.

In order to follow intelligently the story of Cook's discovery, it is necessary to note with some care the dates of the *Endeavour's* voyage — particularly the length of time she was at sea between ports. She sailed down the river from Deptford, and on *August 26,* the wind being favourable, she left Plymouth and made for the South Atlantic. On *September 13* she landed at Madeira. At sea only three weeks — not time

enough for scurvy in that hop! Cook particularly emphasizes the cordial reception they had there, and the fact that he laid in a fresh stock of beef, water, wine, and grapes. On *September 18* he left Madeira. On *November 13,* the supply of provisions beginning to fall short, he put in at Rio Janeiro, having been at sea about eight weeks.

At Rio there was some discourtesy displayed by the Spanish Viceroy. The Viceroy appears, to Cook's obvious disgust, to have been unimpressed with the transit of Venus. There even seems to have been engendered in his Latin mind a base suspicion that Englishmen would not take all the trouble Cook's party was taking merely to observe the movements of a celestial body; Cook's most extreme plausibility failed to dissuade him from the notion that the sons of Albion were actuated by an ulterior motive. Captain Cook's account of his negotiations with the Viceroy has an unconsciously humorous tinge; it is obvious he did not give a hoot about the Viceroy's opinions of Englishmen. What he wanted was fresh provisions. And finally he managed to obtain them. The point is that they were *fresh.* They included water, melons, oranges, and lemons.

On *December 7* the *Endeavour* left the harbour of Rio Janeiro.[1] On *January 14, 1769* they landed at the Bay of Good Success, Tierra del Fuego. Here again the crew went ashore, ate shellfish, and presumably gathered some plants. On *January 26* the *Endeavour* left Cape Horn, and on *April 13* it anchored at Tahiti. This was a long lapse, but many stops were made at little islands such as Lagoon Islands, Thumb Cap, the Groups, etc.

At Tahiti the natives came out to greet them. They bore branches of a green tree, which the English learned had the same significance as elsewhere: a token of peace and amity. They also brought coconuts and various kinds of fruit, "which after our long voyage were very acceptable."

In Tahiti the expedition stayed three months. The transit of Venus was advantageously observed. On July 13, 1769, the *Endeavour* weighed anchor and prepared to attempt to discover the Southern Continent.

No lurid detail with which a modern traveller in the South Seas embroiders his narrative is omitted from this first one. The white men who "went native" are punctiliously included. Four days after the

[1] Not, however, without the Viceroy's having the satisfaction of firing two cannon-balls at them from the fort.

ship departed, two of the marines were found to have deserted. When discovered, and only by taking the person of a native chieftain into custody was this effected, it was disclosed they had decided to take up a permanent residence on the island. " Love," as the eighteenth-century historian puts it, " was the seducer of the mariners. So strong was the attachment which they had formed to a couple of native girls that . . ." and so forth, and so forth.

Only the familiar figure of the debauched scion of the noble house, clothed in tattered white duck trousers and sweaty shirt, unshaven and unkempt, lurching along the beach, clutching a half-empty gin-bottle to his breast, is wanted to complete the *mise en scène* which might, except for the costumes, be lifted bodily into the movies.

The final touch was a master-stroke. I am informed by present-day travellers to Hawaii that when after their visit they are borne away from the shore, even though they leave behind no person they have known longer that a brief summer's vacation, it is impossible to prevent the tears from welling to their eyes. With a fine regard to traditions yet to be created, the crew of the *Endeavour* enacted this very scene. There is a Gilbertian and Sullivanistic touch to it, which requires a daintier pen than mine. Only in broad strokes may I attempt it. As the vessel drew away from the group of affable natives in their canoes, singing and waving to them, we have the spectacle of the hardened crew who had ravaged their women, flogged their men for stealing tenpenny nails, held their chieftains prisoner, fired musketry into their mobs, mocked their religion, and lived bounteously on their hospitality lined up in formation on the deck of the *Endeavour,* all bitterly weeping.

" Our sailors very seldom cry
And yet — I need not tell you why
A tear drop dews each marine eye "
(*Command in an aside*)
" Weep, weep — all weep."

This scene, which must melt all but the hardest heart, dissolved, and on October 6, 1769, nearly three months later, they sight New Zealand and prepare to land. This period at sea would, under ordinary circumstances in those days, inevitably result in an outbreak of scurvy. Yet so far not one of Cook's crew had been affected. But the important fact must be remembered that their course was thickly dotted with little

islands. They landed frequently and obtained fresh provisions. And it must be further noted that these were tropical islands where fruits grew in great abundance. On August 5, we have the particular record of the King of Bola-Bola sending out to the ship a present of fowls, plaintains, coconuts, and other refreshments.

"Enter natives, bearing fruit," that ancient *instruction du ballet,* is really the plot of our story.

Exactly when the idea that it was the fresh fruit that kept his men free from scurvy entered Cook's mind no one can say. He is reticent

Enter natives, bearing fruit.

about his internal mental operations, discursive as he may be about such objective details as the appearance of the country, its animals, inhabitants, and plants. But it is notable that he always mentions in his account of any island or port the kind of fruit to be obtained and even the price of obtaining it. For instance, in describing Batavia he makes this notation:

"Sweet oranges. These are very good, but while we were here sold for six pence a piece.

"Lemons. These were very scarce, but the want of them was amply compensated by the plenty of limes.

"Limes. These were excellent and to be bought at about twelve pence a hundred."

And when cruising about the coast of New Zealand in March 1770 he writes:

"Our people who had been long at sea ate wild celery, and a kind of cresses, which grew in great abundance upon all parts of the seashore.

"Also a green like Lamb's quarters."

Somewhere or other, I fancy, the association of facts came to him. His voyage had been notably free from scurvy. He must have asked himself: "What is the reason?" Was it because of his regulations for cleanliness and ventilation? Or could it be because so many short stops were made at islands and fresh fruit was thus regularly obtained?

However or whenever it occurred, the knowledge takes definite form in his diary three months after he left New Zealand, when this entry occurs:

"June 15, 1770: The scurvy now began to make its appearance among us, with many formidable symptoms. One poor Indian, Tupia, who had some time before complained that his gums were sore and swelled, and who had taken plentifully of our lemon juice by the surgeon's direction, had now livid spots upon his legs and other indubitable testimonies that the disease had made rapid progress, notwithstanding all our remedies, among which the bark had been liberally administered. Mr. Green, our astronomer, was also declining — and these among other things imbittered the delay which prevented our going ashore."

September 18, 1770, when at the island of Timor, there is no shadow of doubt of cause and effect:

"The natives produced some palm wine, the fresh unfermented juice of the tree — hopes were conceived that it might contribute to recover our sick from the scurvy."

On June 12, 1771, Cook and his ship and his crew landed again in England at Deal. On this voyage he lost no men until he reached Batavia, where, owing to shockingly unsanitary conditions, seven men were carried off; more, however, by fever than by scurvy. On the return trip from the Cape of Good Hope twenty-three more men died, some from fever and some from scurvy.

Even so, it was a remarkable record, and on his second voyage, which he undertook on July 13, 1772, and which charted "the main outlines of the southern portions of the globe substantially as they are known today," he was away from England over three years and lost only one man in a crew of 118 from scurvy.

"He had conquered scurvy."

He was rewarded ("meanly," think his devoted biographers) by being raised to the rank of Captain, and by receiving the Copley Gold Medal from the Royal Society for the best experimental paper of the year.

The paper was on the prevention of scurvy at sea, and from it the following extracts are taken:

"Having been absent from England three years and eighteen days, in which time and under all changes of climate I lost but four men, and only one of them by sickness, it may not be amiss to enumerate the sev-

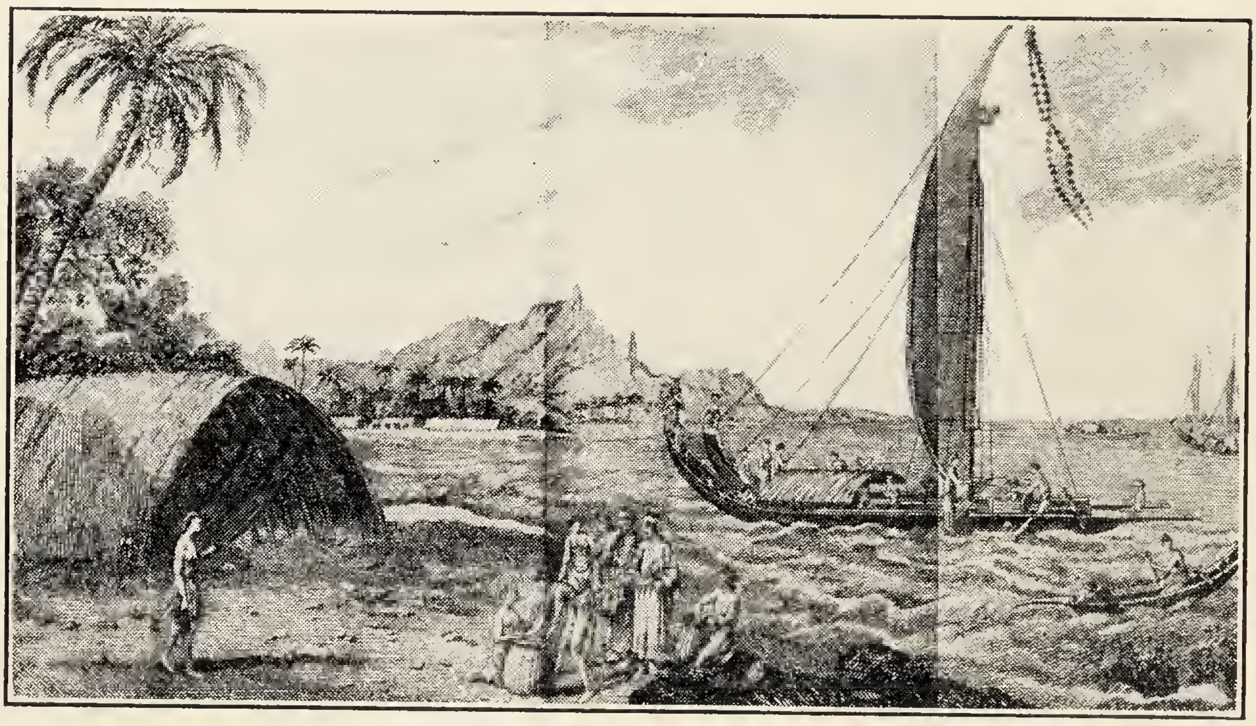


Plate from Cook's Voyages *showing the natives of the island of Ulietea preparing fruit juices.*

eral causes to which, under the care of Providence, I conceive this uncommon good state of health was owing.

"We were furnished with a quantity of malt, of which was made Sweet Wort. To such of the men as showed the least symptoms of the scurvy, and also to such as were thought to be threatened with that disorder, this was given, from one to three pints a day for each man, or in such proportion as the surgeon found necessary, which sometimes amounted to three quarts. This is, without doubt, one of the best antiscorbutic sea-medicines yet discovered; and if used in time will, with proper attention to other things, I am persuaded, prevent the scurvy from making any great progress for a considerable while.

"Sour Krout, of which we had a large quantity, is not only a wholesome vegetable food, but, in my judgment, highly antiscorbutic; and it

spoils not by keeping. A pound of this was served to each, when at sea, twice a week, or oftener, as was thought necessary.

"Rob (concentrated juice) of Lemon and Orange is an antiscorbutic we were not without. The surgeon made use of it in many cases with great success.

"I was careful to take in water wherever it was to be got, even though we did not want it, because I look upon fresh water from the shore to be more wholesome than that which has been kept some time on board a ship.

"We came to few places where either the art of man or the bounty of nature had not provided some sort of refreshment or other, either in the animal or vegetable way. It was my first care to procure whatever of any kind could be met with by every means in my power, and to oblige our people to make use thereof, both by my example and by my authority; but the benefits arising from refreshments of any kind soon became so obvious that I had little occasion to recommend the one or to exert the other."

Priority in the *idea* of the prevention of scurvy naturally goes to Woodall and Lind. But the proof of the pudding is in the eating in practical medicine more than anywhere else. Sir John Pringle was president of the Royal Society when Cook read his paper there. Sir John Pringle had been Surgeon General of the English Army and was deeply versed in the subject of hygiene in armies and navies. He was also a contemporary of Lind's, who was surgeon to the Royal Navy Hospital at the time Cook returned from all his voyages. In presenting the Copley Medal to Cook before the Royal Society, Sir John Pringle said: "Here are no vain boastings of the empiric, nor ingenious and delusive theories of the dogmatist: but a concise and artless, and an incontested relation of the means, by which, under divine favour, Captain Cook, with a company of one hundred and eighteen men, performed a voyage of three years and eighteen days throughout all the climates, with the loss of only one man by sickness."

There is the matter in a nutshell. Cook did it. He made the journey and he prevented scurvy.

It was nearly twenty years before the lesson was fully learned. In 1779, three years after his Royal Society paper, the Channel fleet had 2,400 cases of scurvy after a ten weeks' cruise. But in 1795 Sir Gilbert Blane, when he was appointed to the Navy Medical Board of the Ad-

miralty, was instrumental in having an Admiralty order issued making lemon juice a necessary ration in the British Navy.

In 1803 Trotter wrote: "A case of scurvy requiring to be sent to hospital has not come under my observation since 1795."

Even down to a century later Great Britain's Merchant Shipping Act contains a section devoted to the furnishing of antiscorbutics, of which the first clause states that they shall be lime and lemon juice.

CHAPTER XV

HUMANITARIAN MEDICINE AND SANITATION

On a summer day in 1786, in the Turkish seaport town of Smyrna, an Englishman named John Howard might have been seen threading his way among the bales of goods and objects of shipping along the docks. Every once in a while he would stop and order his interpreter to engage some idle sailor in conversation. As he did so, the sailor's eyes would widen in astonishment, and as they walked away, he would grin at the Englishman's back and tap his forehead with his forefinger.

The Englishman unquestionably was making a queer request. He wanted to take passage for Venice, but only on a vessel with a "poor bill of health." In other words, a vessel which had recently carried a patient with the plague or which had had an epidemic of ship fever aboard. Such a vessel would be detained in quarantine in Venice and such passengers as were allowed to alight would be required by the authorities to spend a period of time in the lazar-house, or public hospital, before being allowed the freedom of the city.

And this is precisely what John Howard wanted to do.

He had behind him a long career full of such acts — a long career of busying himself in other people's business. He bore the unpopularity which such a career involves with humility, and even with a little pride and satisfaction. Because by doing so Mr. Howard was absolutely, positively certain that he was on the way to heaven.

His first busybodying had been carried out in the investigations of prisons and jails. The conditions which he found to exist in these institutions had aroused the indignation of a righteous England.

The worst part of the jail situation he had found to be the system

whereby the prisoners paid the jailer for their accommodation, food and drink. Hence jailers were loath to have them depart and obstructed justice, prevented fair trials, and frustrated attempts at pardons.

With the details of such abuses we have nothing to do in this narrative, but other things which Mr. Howard found do concern us. The living conditions in jails were so filthy that he came to the conclusion that they were responsible for the high rate of sickness and death inside those walls. Prisoners were crowded together so that, day or night, one was hardly out of touch with his filthy companion. The walls were high, the windows small, and the air consequently stale and stinking. Remnants of food and human excreta lay upon the dirty floors for weeks. There was no fresh water. Often there was no water at all. What little there was sufficed only for drinking. The persons and garments of the prisoners were filthy, and consequently they attracted lice, fleas, mice, rats, and vermin of all sorts. All this Mr. Howard pointed out.

It is, of course, astonishing to modern minds that anyone could doubt that this bred disease. But in the minds of our ancestors no such association existed. The condition of the streets, the yards, the public buildings, even the best-cared-for homes of those times was dirty beyond belief.

A rainfall is to us a blessing because it helps the growth of crops and vegetation. But in the eighteenth century we have documentary evidence that it was welcomed for another reason. Swift described it thus:

"Now from all parts the swelling kennels flow,
And bear their trophies with them as they go;
Filth of all hues and odours seems to tell
What street they sailed from, by their sight or smell;
Sweepings from butchers' stalls, dung, guts and blood,
Drowned puppies, stinking sprats, all drenched in mud,
Dead cats and turnip-tops come tumbling down the flood."

Mr. Howard's idea that these conditions caused disease bore fruit in the reform of prison conditions, and then he turned his attention to hospitals — lazarettos, he called them (the word being derived from Lazarus), lazar-houses, or houses for the sick.

He visited these in all countries, and in the course of his investigations he made his way to the pestilential Orient, the mother of all

plagues and epidemics. In Malta he found about five hundred patients in the hospital, "served by the most dirty, ragged, unfeeling and inhumane persons I ever saw." There were twenty-two of these attendants for five hundred patients. "At the same time, I observed that near forty attendants were kept to take care of about twenty-six horses and the same number of mules in the Grand Master's stables: and that *there* all was clean. I cannot help adding that in the centre of each of these stables there was a fountain, out of which water was constantly running into a stone basin, but that in the hospital, though there was indeed a place for a fountain, there was no water. . . .

"At Galatea I found the sick lying on the floors. All were neglected: for none of the faculty would attend them. In the midst, however, of this neglect of human beings, I saw an *asylum for cats.*"

Mr. Howard had a reporter's eye, but such acuity does not make for popularity among the authorities. A report spread like a miasma around the Mediterranean basin that there was a thin-lipped Englishman who wished to visit the lazaretto, and later there would be trouble. Mr. Howard was nothing if not thorough. And apparently the only way he could gain access to the lazaretto of Venice was to put himself in the position to be forcibly interred. Hence his eagerness to find passage on a plague ship.

His plan succeeded, and, like a collector of first editions, he soon had another item — the record of another dirty hospital.

When death overtook him, an event which he regarded with a smug satisfaction characteristic of the worst breed of eighteenth-century evangelicalism, he had the consciousness that his labours had been successful. Although reforms of that kind move slowly, prisons and hospitals had been brought into the focus of public vision. Their inmates were no longer regarded as beyond the range of human thought and care.

Not only that, but the whole idea of modern sanitation was accelerated by Howard's work. (It is not quite accurate to say it was initiated by him.) Three other Englishmen were leaders in this movement — Sir John Pringle, James Lind, and our old friend the perpetual curate of Teddington, Stephen Hales. That they who were associated with the basic idea of cleanliness should be Englishmen is natural, but there were other motives. Sir John Pringle was Surgeon General of the English Army (1742–58); and Britain's armies were marching off

to defend and solidify her newly far-flung Empire. Where Britain's soldiers went, they must be healthy. Public sentiment demanded that.

The great scourge of armies, then and now, was epidemics of fever, dysentery, and influenza. Sir John Pringle showed that jail fever and hospital fever were identical — probably typhus fever spread by lice. He named influenza and classified the dysenteries. He thought "putrefaction of the air, of all causes of sickness, perhaps the most fatal and the least understood." And he took measures to prevent the exposure of troops to corrupted air (1) arising from marshes, (2) from human

Mr. Howard's ideal for a quarantine hospital. It should have "a cheerful aspect, a spacious and pleasant garden in particular," but be isolated so that any traveller who should develop a contagious disease during his detention would not communicate it to the inhabitants. Mr. Howard thought it unnecessary to detain a traveller in quarantine very long; twenty-two days at each port was enough, he thought.

excrements, lying about camp when dysentery is present, (3) from rotting straw in the tents, and (4) breathed in crowded hospitals.

Sir John was wrong in his idea that the air itself caused the epidemics. The foul air was only a guide to the real sources of trouble. But in those four measures he had the basis of the prevention of malaria, dysentery, and typhoid fever, tetanus, and typhus, and contact infection of the respiratory tract, such as influenza, pneumonia, and measles.

James Lind was a sailor. And Britain was ruling the waves. As a matter of economy, her sailors must be kept alive and healthy. One of James Lind's ideas, as we have seen, was the recommendation of a daily ration of the juice of lemons to prevent the scurvy. On board ship he instituted

good food, cleanliness, ventilation, fresh bedding, and destruction of vermin, as the order of the day.

With ventilation the first work was done by Stephen Hales. He heard that an epidemic disease had broken out among troops on board ship at Spithead, lying embarked for an expedition to America. He conceived the idea that such occurrences were due to the foul stinking air

Ventilator designed by the Reverend Stephen Hales, erected in 1752 over the gateway of Newgate Prison. It brought up air from the foul close rooms in the prison. (*Print in the British Museum*)

in quarters below decks, and constructed a ventilator (a sort of bellows arrangement) to suck this air up and allow fresh air to enter through the port-holes. The Admiralty, however, with their genius for such mental exercises, found objections to it and to another similar device independently invented by a Mr. Sutton.

Dr. Hales kept on with this idea, trying to place ventilators in hospitals and jails. Lord Egmont saw at the hospital Dr. Hales's ventilator or engine for recruiting the sick persons' apartments with fresh air,

"which on occasion will draw the tainted air of three stories out in the space of half an hour and supply its place with fresh air."

"A noble invention," comments my lord, "which would be of great use at sea for hospital ships"; but again that incorrigible Admiralty levity: "Sir Jacob laughs at it."

In 1740 a most unfortunate accident quenched the official titters. Wearers of the ermine were found to be as much exposed to danger as malefactors. During the May session at the Old Bailey an infectious disorder among the prisoners who were brought into court was communicated to a number of the judges, counsellors, sheriffs, and jurors. Sixty-four of these gentry lost their lives. In the face of this appalling tragedy a sheriff consulted "that excellent pattern of humanity," Dr. S. Hales.

What occurred gives us some idea of the length of the road sanitary science has come in two hundred years. The jail was ordered to be cleansed thoroughly. "Three cartloads of the most abominable filth were carried away, but lest the effluvia of such poisons should infect the outside air, the Sheriff had it carried a considerable distance from town and there buried ten feet under ground. After this he went into the dismal jail itself and ordered it to be washed with vinegar, and likewise the prisoners, *before being brought down to the Old Bailey to take their trials.*" (The italics are mine.) There was to be no more infecting of judges and sheriffs. "Dr. Hales had certain herbs burnt in the court for some days before the Sessions began."

Here we have the beginnings of fumigation, and recognition of the communication of diseases through contact, foul air, and filth.

A few other items belong properly here and may be briefly noticed.

An Italian named Ramazinni in 1700 opened up a new department in modern preventive medicine by calling attention to diseases caused by special trades or industries. Stone-mason's consumption, the eye troubles of gilders, wool-sorter's disease, potter's sciatica, painter's colic, were shown to be more than verbal linkings. In the various English publications usually called "A Book of Trades," which were intended to give parents and the youths themselves a general description of the trades young men might enter, there are plain warnings about these occupational diseases, and suggestions for preventing them. Lead poisoning in painters was especially noted. But only measures carried out by the individual — cleanliness, changing clothes, and the like —

are recorded as preventive measures. Not yet did enlightened public interest compel the employer to enforce precautionary measures.

Poisoning of large numbers of people from contamination of food was given prominence by a dramatic exposure of the source of lead poisoning in 1772. Lead, as we now know, may be absorbed into the body either in solution through the digestive system or in gaseous state through the lungs and produces quite definite changes. Metallic

The house-painter. An illustration in one of the old English Books of Trades. These books were planned to aid parents in selecting an occupation for their children, and besides describing the manner of apprenticeship they also warned against the diseases incident to each trade. These are among the earliest accounts of such occupational diseases as lead poisoning.

lead under these circumstances is deposited in the gums — the so-called lead line — and in the red blood-cells — stipple cells. It causes a weakness of the arms — wrist drop — and especially paroxysms of pain in the abdomen — lead colic.

For many years there was a disease in Devon, "more or less every autumn," when cider was in season, called "Devonshire colic." Both the name and the suspicion that it was caused by Devonshire cider were bitterly resented by the natives of that region. Their cider, they said, was just as good as anybody else's cider. And made the same way. In that

last statement they overplayed their hand, because Sir George Baker, himself a Devonian, showed that in the parish of Bury Pomeroy the cider was stored in a large leaden cistern. The cider of Herefordshire did not cause colic, and Baker, in the course of his investigation, found that the only difference in the preparation of cider in the two counties was that in Devon it was the common practice to line the cider-presses with lead. Finally he produced the conclusive proof by showing that lead could be extracted from Devon cider, but not from the cider of Herefordshire.

Like most people who appear to be enemies but are really friends of an industry, he was roundly abused and called a "faithless son of Devon," but he established early an example of preventing disease at its source — now the ideal of all organized medicine.

The disposal of human excreta and waste — the first principle of modern sanitation — was a problem which required a long period for sensible treatment. Public sewers, garbage-destruction, plumbing, and sewage disposal are matters whose origin is within memory.

The history of the watercloset is an example of human endurance. Actually proposed by Sir John Harington in the time of Queen Elizabeth, it waited several hundred years to be adopted. Sir John was moved by his sensitive nose and the proximity of the privy or "jacks," as it was familiarly called, *inside his house* in Bath to propose a watercloset, for which he drew the specifications, publishing it to the world in a book with the punning title of *The Metamorphosis of Ajax.*

But the proposal did not catch hold. Then, as before and after, fæces and urine were deposited in privies and chamber-pots. The pots were emptied into the streets or against the walls of the cellar; the privies might be inside or outside the house. Besides the general olfactory offence, these habits lead directly to disease by contaminating walls and cisterns.

The famous case of the Broad Street pump illustrates both the fact and the comparatively recent date of such practices. Cholera broke out in London in 1854 and was localized particularly in the district around Broad Street. The drinking-water of this district was supplied by a well in Broad Street. Near by, a few weeks before, a man had died of cholera. Investigation showed that during his illness his bowel movements were thrown in a privy vault which drained directly into the ground near the well, and that the mortar around the old stone joints of the well

had fallen out so that the seepage from the privies passed into the drinking water of the common pump. It is the first case recorded where the spread of disease was traced to water.

Unless you have a method of check, a standard of comparison, how can you tell whether you are preventing disease or not? With this idea rose the use of vital statistics. Two names are particularly associated with their development. Captain John Graunt in 1662 published his observations made upon Bills of Mortality. These Bills of Mortality were lists of burials, marriages, and baptisms. From their study Graunt demonstrated, according to Dr. Raymond Pearl, four of the most important facts which the study of vital statistics to this day has disclosed: First, he made clear the regularity of certain vital phenomena which appear to be merely the play of chance in their individual occurrence. Second, he pointed out the excess of male over female births, and the approximately equal numbers of the sexes in the population. Third, he demonstrated the relatively high rate of mortality in the earliest years of life. And, finally, he discovered that the urban is higher than the rural death-rate normally.

William Farr spent a long life in the Registrar General's office studying columns of figures of deaths, births, and incidence of sickness. He taught himself most of the mathematics he knew, and became in his field one of the distinguished mathematicians of all time. His most important generalization is known as "Farr's law." This states that during an epidemic of disease the number of cases at first rises rapidly, then slowly, to a maximum and then descends more rapidly than it rose. He plotted it on the smallpox epidemic of 1840 and from it predicted successfully the subsidence of the cattle plague of 1865–6.

PART VI

SCIENCE AND PRACTICE UNITED

Towards the end of the eighteenth and the beginning of the nineteenth centuries a social change began to come over the spirit of medical practice. It can be put briefly, probably best, by saying that it ceased to be a trade and began to become a profession.

The chief cause of this was the weight of accumulating knowledge; it became too complicated to be acquired through an apprenticeship. So medical schools in the modern sense of the term were established. It is notable that they were formed at hospitals rather than universities — the teachers were men acquainted with the realities of wards and sick-rooms, rather than theorists whose only claim to fame was an elaborate system.

But certain dominating personalities also were instrumental in forcing the change. One was John Hunter. Even more powerful was the influence of Jean Nicolas Corvisart, Napoleon's physician.

The years 1810 to 1820 were, according to my learned friend Doctor Leroy Crummer, the most critical medicine ever encountered. 1810 was the date of the publication of Hahnemann's Organon, *which enunciated the doctrines of homœopathy, and 1821 was the date of Hahnemann's removal from Leipzig, his principles repudiated by the orthodox medical world.*

Hahnemann's effect on his time was very profound. Scientifically unsound, he yet had the ability to create in his fellows a sort of passionate devotion to the integrities of the relation between patient and physi-

cian. Most practising physicians then were quacks. At least they were business men. They guarded secret remedies. It is fair to say that Hahnemann did much to change that.

Corvisart had, however, not only those same deep moral convictions, but also clear scientific judgment. He recognized the significance of the new methods of physical diagnosis — percussion and auscultation — introduced by Auenbrugger and his own pupil Laennec. And in fitting men for practice he developed the Paris school of medicine.

No other school has ever had as much influence. Medical aspirants from all countries came to Paris. The important Irish school — Graves, Corrigan, Cheyne, Adams — of the early nineteenth century in Dublin was a direct outgrowth of the French school, as was the English school of Bright, Addison, Hope, Williams, and Hodgkin, and the Scotch school of Stokes and his confreres. Earnest young Americans — Jackson and Oliver Wendell Holmes, for examples — returned from their Parisian studies full of enthusiasm which still operates on these shores.

In 1821 Corvisart died, and Hahnemann left Leipzig, and soon the reign of the business men was over. The medical profession ceased to have secrets. All its members gladly share their accumulated knowledge with each other.

Diagnosis and treatment became part of biology.

CHAPTER XVI

SCIENCE AND SURGERY—JOHN HUNTER

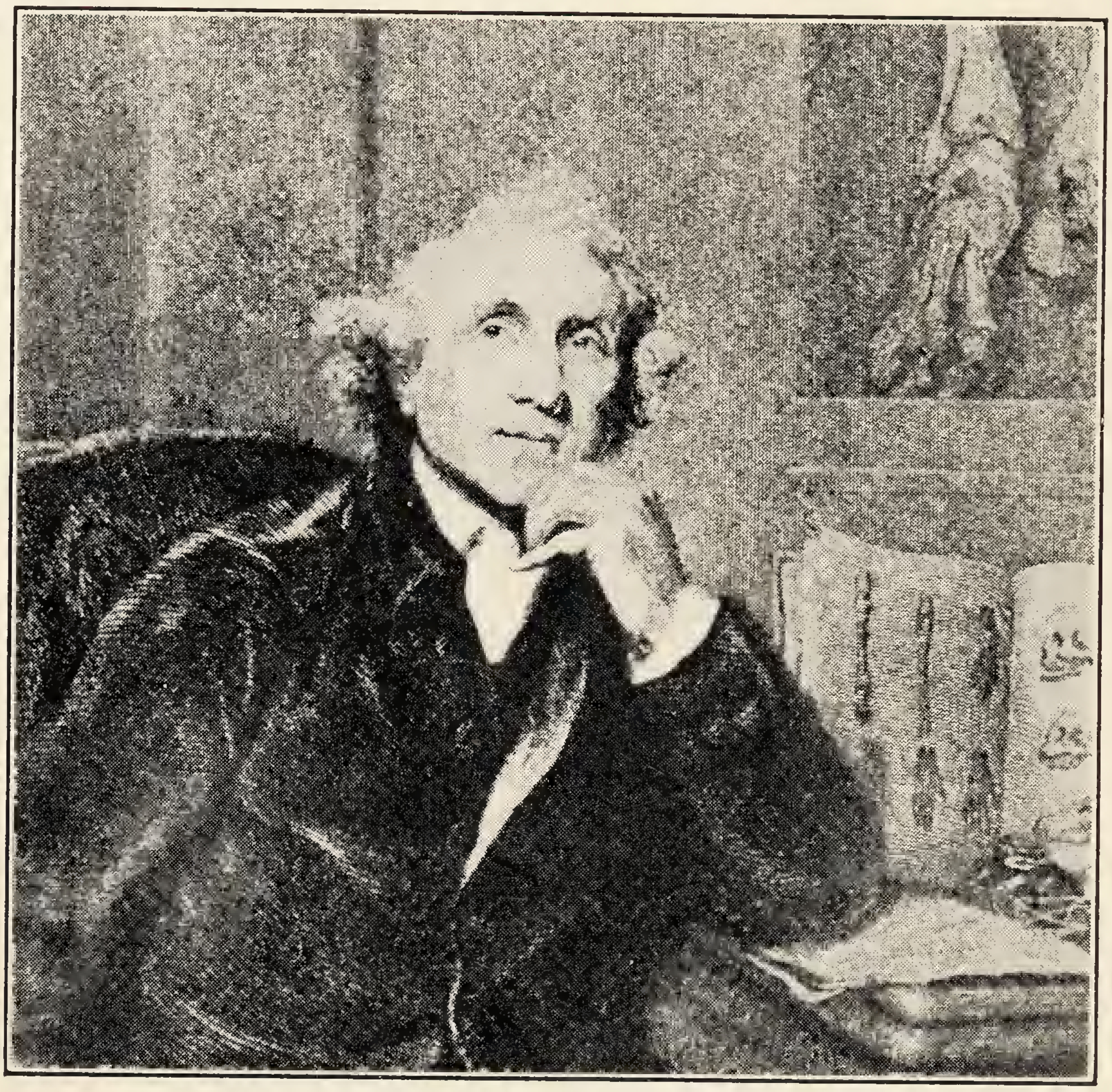
Mr. John Hunter, the surgeon, had been arguing. He stood now with his legs apart, his back to the fire, lifting up his coat-tails to the heat. To one who knew Mr. Hunter there was a glint in his eye which indicated he was losing his rather unstable temper.

The florid, plump, bewildered man of thirty-five who sat before him was staring stubbornly ahead. He had been driven to resist Mr. Hunter's arguments by silence.

The experience indeed had been a most unsettling one. When his father had fallen ill a few weeks before, he had been assured that Mr. Hunter was the most skilful practitioner then in London — it was the early spring of 1788. So, being a man of means, he employed Mr. Hunter in consultation. And Mr. Hunter had failed him, for his father had died, and all that was mortal of him lay upstairs on the wide bed, covered by a sheet.

In the first shock of bereavement Mr. Hunter had been very gentle. He had assisted him downstairs and poured him a glass of tawny port to give him a little control and strength. His loss was great and almost insupportable. It was almost impossible for him to realize that his father's strong and imperious personality was no more, that his wise old voice was for ever stilled and could counsel him no longer, that all the responsibility of the business and the family was now on his own unworthy shoulders. He explained as much, brokenly, to Mr. Hunter and to young Mr. Abernethy, Mr. Hunter's assistant, who was with him. He was, indeed, if ever a man could be expected to be so, an object for pity.

But, suddenly, Mr. Hunter had made a very strange request. It puzzled him. Mr. Hunter had asked permission to open his father's body in order to examine into the cause of death. The effect was unpleasant. Here Mr. Hunter had been touted to him as the cleverest of practitioners, and with what disastrous results! And now it appeared that Mr. Hunter did not even know what the disease was from which



John Hunter (1728–93).

his father had died, and proposed to use the body to satisfy his ghoulish curiosity.

The thing revolted him. And he refused. Mr. Hunter had argued. He had at first attempted to reply, but Mr. Hunter seemed always to get round him. So now he sat in stolid silence, and Mr. Hunter warmed his legs before the fire, the dangerous gleam playing in his blue Scotch eyes.

"Then, sir," says Mr. Hunter, evenly, at the last, "you will not permit the examination to be made?"

"It is impossible," responded the helplessly bewildered merchant.

"Then, sir," said Mr. Hunter, breaking into a sea of anger, "I heartily

hope that yourself and all your family, nay, all your friends, may die of the same disease, and that no one may be able to afford any assistance."

And having pronounced this dreadful doom upon the poor gentleman, "so saying he departed," concludes young Mr. Abernethy, the veritable chronicler of the anecdote.

It was one of the few instances, we are told, when Mr. Hunter was ever brutal towards his patients or their friends. And most people, I suppose, will feel their sympathy going out towards the unhappily bereaved son rather than to Mr. John Hunter.

But it must be remembered that Mr. Hunter was fighting for the great central sanctity of his life — and in these circumstances a man of his temperament does not suffer fools gladly. That central sanctity was, of course, the right to a free and independent investigation of nature in all her aspects. Mr. Hunter, who bore the same relation to medical London in his day as Samuel Johnson did in that same period to literary London, went through his earthly pilgrimage with the fierce light of that preeminence burning in his countenance. He exercised the privilege of investigating nature where he found her. You might have discovered him lying on his belly near a fish-pond to determine if fish could hear, or in that two-acre garden of his house at Earl's Court on the outskirts of London, up to his armpits in the dissection of a whale brought him from Greenland, while zebras and panthers wandered all around him.[1]

"Cannot you get me a large porpoise for love or money?" he writes Edward Jenner, the discoverer of smallpox vaccination. Jenner, by head and shoulders the greatest medical man of his time, was always faintly patronized by Hunter. Hunter sent him into Gloucester to set up in practice. When Jenner consulted him about the value of vaccination, Hunter wrote him the words which have become the motto of experimental science: "Don't think, try; be patient, be accurate." Hunter and Jenner engaged in a lifelong correspondence — which racily reflects Hunter's restless activities.

"What do you think of examining eels? Their sexes have not yet been found out."

"Have you any eaves where bats go at night? If you have I will put

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[1] "In the garden of Mr. Hunter, surgeon, at Earl's Court, are seen buffalo, rams, and sheep from Turkey, and a shawl goat from the East Indies, all feeding together in the greatest harmony: besides a prodigious variety of other beasts and birds supposed to be naturally hostile to each other." (*London Morning Post,* August 30, 1793.)

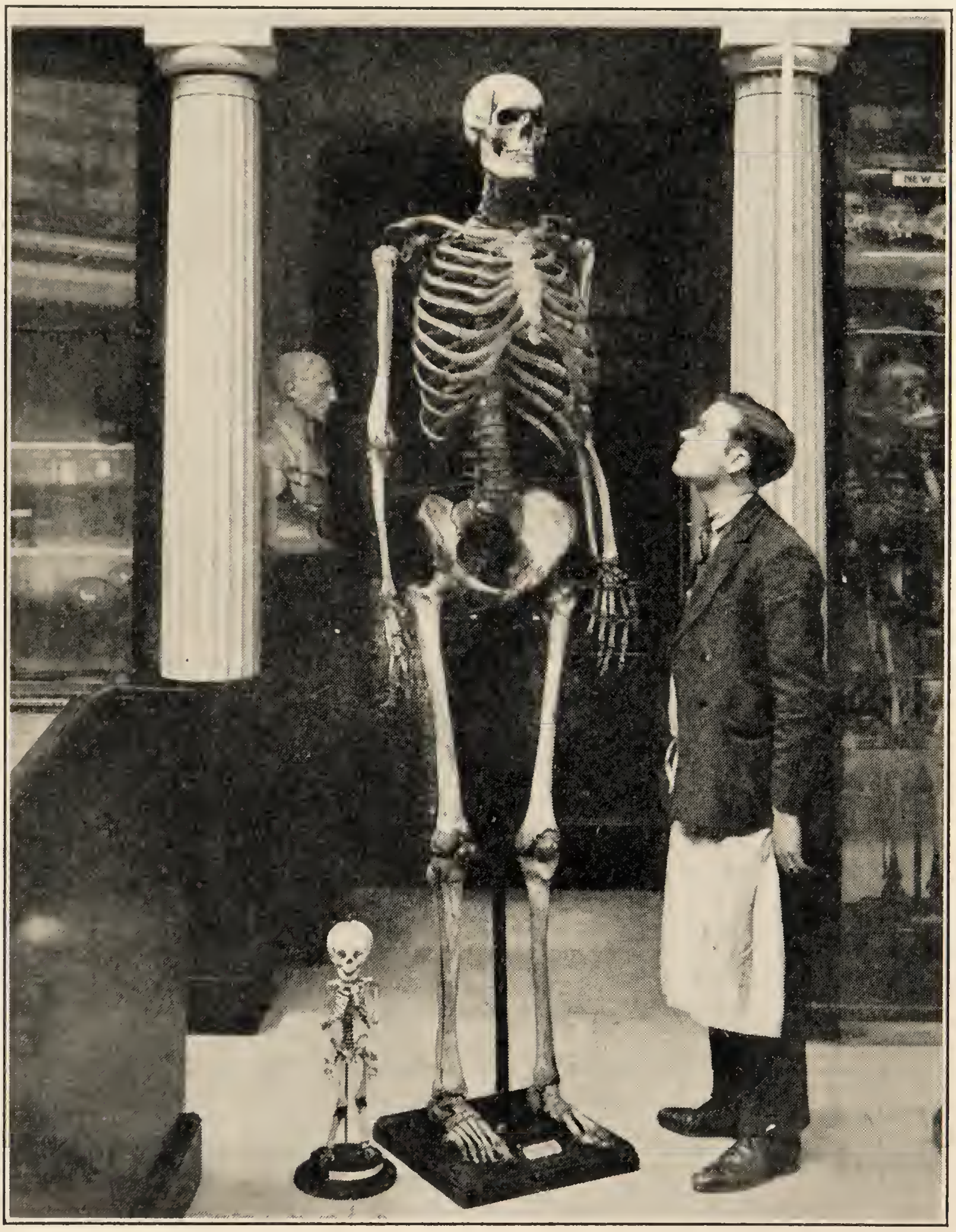
you upon a set of experiments concerning the heat of them at different seasons."

Such was the nature of the suggestions John Hunter showered on his bucolic protégé.

Had you lived in London in 1783 you might have seen John Hunter looking lasciviously at O'Brien, the Irish Giant, who was on exhibition at a raree-show. Mr. Hunter had gone to see the giant as a medical curiosity and had been interested. He wondered what a giant's skeleton looked like. They had dropped into conversation, and Mr. Hunter had remarked that giants did not usually live long and that he would esteem it an especial favour if O'Brien would consent to allow his body to be dissected after death. This suggestion terminated their conversation and acquaintance abruptly, for the giant had a superstitious horror of being dissected and was not particularly pleased at the thought of early death.

Mr. Hunter's particular interest was re-excited when the state of health of the towering prodigy began to decline. The contemporary records state that O'Brien died from alcoholism and tuberculosis, but our present knowledge of his form of giantism makes it probable that he had a tumour of the pituitary gland. Whatever the cause, the symptoms of disruption of his frame were evident even to O'Brien himself. The poor frightened giant found Mr. Hunter's eyes glinting at him from every alleyway. He moved from lodging to lodging to escape him. In every new place he thought for a time he was safe; but inevitably some day he would leave his house and spy that sinister figure peering from a neighbouring doorway. Mr. Hunter set his servant Howison to shadow the quarry. And as the giant was eight feet, four inches tall, the task was not difficult. The gangling monster whinnied with terror whenever little five foot two inch Mr. Hunter hove in view. Whimpering on his deathbed, he left orders that his body should be watched day and night until a leaden coffin had been prepared, and that it was then to be taken in a vessel into the middle of the Irish Channel and sunk. Having thus prepared himself, he died, but he reckoned without John Hunter. The faithful Howison learned the details of the affair and plied one of the watchers with strong drink and found he could be bribed to allow the body to be kidnapped. Fifty pounds was at first demanded, but, finding Mr. Hunter's appetite so keen, the price soared until it came to five hundred pounds. The money had to be borrowed, but it was obtained and the body hustled into a hackney-coach "at dead of night."

The hackney-coach dashed through several streets. Then its pace became slower and it drew up beside a carriage waiting at a curb. The spot was prearranged. It was Mr. Hunter's own carriage. Those glistening eyes at the carriage window were his. He had his quarry at last.



Skeleton of the Irish Giant, in the Hunterian Museum, Royal College of Surgeons, London. Average-sized man and skeleton of dwarf for comparison.

The body of the giant was bundled into Mr. Hunter's carriage, and, there, clinging to his eight and a half feet of treasure, Mr. Hunter drove out of the London streets to Earl's Court and boiled his trove in a vat. The bones of the Irish giant do not lie at the bottom of the Irish

Channel. They stand articulated in the museum of the Royal College of Surgeons, London.

Yes, John Hunter was a dangerous man when stalking quarry. A certain Dr. Clarke had a specimen which Hunter coveted. "Come, doctor," he said, "I positively must have that preparation."

"No, John Hunter," was the reply, "you positively shall not."

"You will not give it to me, then?"

"No."

"Will you sell it?"

"No."

"Well, then, take care I don't meet you with it in some dark lane at night, for if I do, I'll murder you to get it."

He did not even spare his own person in this agony of curiosity about nature's secrets. He inoculated himself with syphilis and refused treatment that he might observe the course of the disease in his own person. He wrote a treatise on the subject. Today the chancre, the first site of the entrance of the syphilitic virus into the body and the first manifestation of its activity, is known as the "Hunterian chancre."

"Pray, George," said he to his friend Nicol, the bookseller, "have you got five guineas in your pocket? Because if you have and will lend it to me, you shall go halves."

"Halves in what?"

"Why, halves in a magnificent tiger which is now dying in Castle Street."

"The hedgehogs came," he wrote Jenner in 1778, "with one dead, which was a female, which I made a preparation of. . . . I was told the other day that you was married and to a young lady with a considerable fortune. I hope it is true, for I do not know anybody more deserving of one. What is become of your paper on lead in cider?" The new wife, the hedgehogs, and the lead in the cider all mixed together on an even footing. And then wistfully, as if he wondered whether Jenner would pursue his science now that he had a rich wife: "How do the fossils go on?" And again, even more wistfully: "We had a sale of bad pictures lately. Pictures seem to be rising again. I am told there is the skin of a toad in Berkeley Castle that is of prodigious size. Let me know the truth of it, its dimensions, what bones are still in it, *and if it can be stolen by some invisible being.* I buried two toads, last August was a twelvemonth; I opened the grave last October, and they were well

and lively. . . . Have you any queer fish? Amy sends, with little John, their compliments."

And what was the result of all this endless gathering of specimens?

Well, there they are today all in the Hunterian Museum in London. Here is Victor Robinson's eloquent description of it:

"What specimens — thousands upon thousands — dry, in spirits, stuffed, — everything: varieties of the cuticle of different animals, showing how it increases in vascularity in proportion as its sensibility increases; the organs of taste, smell, hearing and sight, exhibited in ascending series. The individual peculiarities of plants and animals, monsters, mummies, the skulls of the five great divisions of the human race, the development of the brain and spinal marrow from the knotted cord of the crustacea upwards through fishes, reptiles and birds, to the brain and spinal cord of the mammalia; teeth, from the beaks of birds to the tusks of boars; specimens showing the effects of various diseases on brains, hearts, lungs, stomachs, intestines, spleens, kidneys — the apotheosis of pathology."

Broad as were his interests in science, they all focused on the processes of disease. If he studied the normal, it was to have a standard for the abnormal. And in his study of disease he found the most valuable method was by means of the post-mortem — the examination of the body after death. Hence his anger before that poor stolid British merchant when we first met him.

"He alone made us gentlemen," said one of his colleagues in surgery. And if he thus raised the social status of surgeons, he did it all the more for pathologists. He put the thing on high ground: a man who opened a dead body was no longer a ghoul, he was a scientist — a student of the order of nature, and, as such, on a plane with every other kind of a student.

There is exactly as much culture to be derived from the study of cirrhotic livers as from the study of the elegies of Tibullus.

The deep influence of Hunter in this respect may be seen in the attitude of his immediate successors. His nephew, Mathew Baillie, published, in 1794, an atlas and text-book on *Morbid Anatomy*. This was the first systematic account of the diseased appearance of the internal organs of the body to appear in print.

One of the plates represents a lung and is an illustration of the disease called "emphysema." The lung was that of Dr. Samuel Johnson: its

state accounts for the "heavy form, rolling," and the "puffing" of Macaulay's description. So the Great Cham is dead, and here is dry little Dr. Baillie cutting him up as if he were any other piece of flesh.

Picture of a lung from Baillie's Atlas of Morbid Anatomy. *According to Dr. Charles Singer, this is Samuel Johnson's lung. The text of the* Atlas, *however, simply says that "the air cells are seen much enlarged beyond their natural size so as to resemble the air cells of the lungs in amphibious animals." The break-down of the walls of the air cells probably caused the shortness of breath which Boswell mentions so frequently as characteristic of the great lexicographer.*

Why not?

See the will of Sir Astley Paston Cooper, surgeon to Guy's Hospital, London. We meet him in another part of this narrative. He lived in the

great Hunterian tradition. Do you suppose that surgeons and physicians who ask to examine a body after death are squeamish about their own personal autopsies? Hear what Sir Astley commanded when he thought he was about to die. "Shortly before his death, Sir Astley Cooper expressed a wish that the appearances which should be presented on the inspection of his body might be recorded in the Guy's Hospital Reports. He had particularly alluded to four points, the investigation of which he

Matthew Baillie (1761–1823). He anatomized Dr. Johnson.

thought desirable — a cured oblique inguinal hernia; some suspected indications of phthisis in his youth; and an inability to sleep whilst lying on his left side."

These points were accordingly investigated on February 13, 1841, at nine o'clock in the evening, thirty-two hours after Sir Astley's death, in the presence, among others, of Doctor Richard Bright.

For myself, I know exactly how Sir Astley felt. It must have been a bitter disappointment to him to realize that he could not be present at the post-mortem himself and with his own eyes see the explanation of those disarrangements of his body with which he was so familiar. But he had no intention of depriving his friends of that pleasure. I know of no post-mortem I should rather attend than my own.[1]

[1] Or hardly any.

CHAPTER XVII

PRECISE METHODS OF DIAGNOSIS AND TREATMENT

1. *Body Squeaks*

Queens have played a consequential role in medical history. Several of their infirmities and accouchements will be found in these pages. When common folk suffer, it is seldom of world-wide moment, but the tenesmus of princes is always hallowed. Thus new cures that have worked on crowned heads or crowned corns always become popularized.

The eighteenth century was a great one for queens. There was Queen Anne in England, and Catherine the Great in Russia, and, finally, Maria Theresa in Austria. Our interest in Maria Theresa concerns a serious difficulty she experienced. In spite of what I presume might euphemistically be called repeated efforts, she did not become pregnant for some years after her marriage. She heard, in this situation, of the great Dr. van Sweiten of Leyden. He was the favourite pupil of that famous Dr. Boerhaave to whom a Chinese official had once written a letter addressed simply "To the Greatest Physician in Europe," which was forthwith delivered to him. Another story about Boerhaave was that he kept Peter the Great sitting all night in his waiting-room for a consultation because he would make no distinction between the rich and the poor. Thus Van Sweiten, his pupil, was used to the atmosphere of emperors.

The Empress sent for Dr. van Sweiten. He came to Vienna. He resolved the problem of the Imperial sterility in his mind. He then drew Her Majesty's husband, Francis of Lorraine, aside and whispered something to him. What he whispered I do not know and I do not want

to know, for the result was that Maria Theresa became pregnant sixteen times in rapid succession.

Van Sweiten naturally obtained the fervid confidence of the Empress. She had dreams of making Vienna a great capital. Van Sweiten persuaded the Empress to found a medical school and he naturally was placed at its head. He was a man of much practical ability. He was made a state counsellor and created a baron. He was prefect of the Imperial Library and wrested the censorship of prohibited books away from the Jesuits.

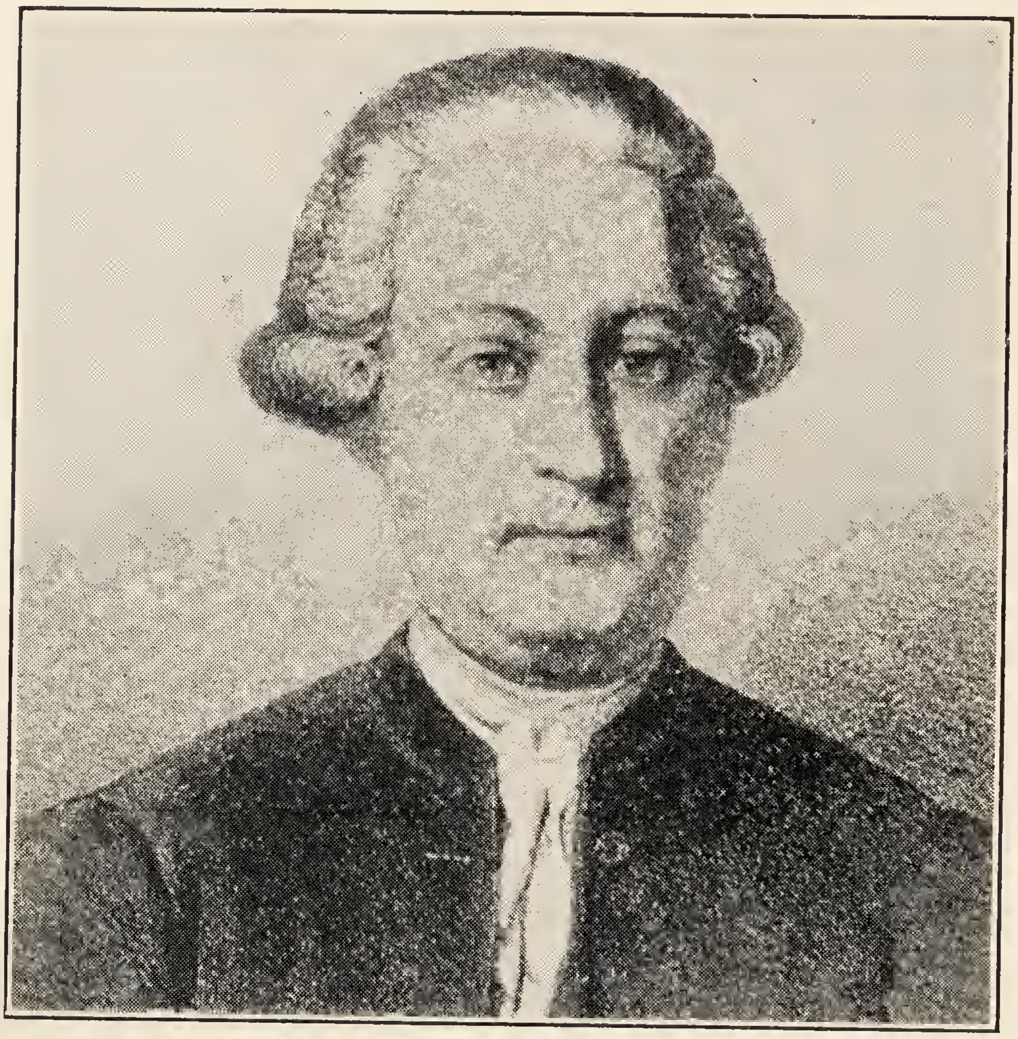
Under Baron van Sweiten the medical school of Vienna grew into one of the most famous in Europe and a source of huge pride to all Austria. He and his colleague, Dr. de Haen, used the method of bedside clinical instruction which their master, Boerhaave, had introduced, with great personal success. Securing large grants of money, this old Vienna school of medicine became of imposing proportions.

Old Vienna was a queer out-of-the-way place in those days — a dirty, gloomy little city surrounded by walls, which occupied the site of the present Ringstrasse. The streets were narrow and winding, the houses on each side so tall that the British attaché, with the oracular frankness of his kind, called them " well-like." It was indeed a very countrified capital when the great Empress and her hen-pecked cousin-husband came to the throne. She was determined to make it of importance, however, and with that mixture of manner and method for which she is famous, she accomplished her purpose. She brought musicians, poets, and actors there — established opera, universities, museums, theatres. And as her husband laconically intimated (they were coming home from the theatre and Her Imperial Highness observed, in the seclusion of the royal carriage, that the actress they had just seen was the greatest in the world; upon which he, husband-like, replied: " After you, madame "), she was herself not the least of the attractions of the capital.

Somewhat about the period of these glorious times, in the Steiermark of Austria, to the south of Vienna, in the little village of Graz, there was born, in 1722, to the innkeeper Auenbrugger, who kept the inn at the sign of the Black Moorish Women, a son, whom he christened Leopold. The inn was prosperous and the father began to have ambitions for his son. The boy was grave and industrious, helping about the kitchens and the wine-cellars. As he grew up, he expressed a desire to become a physician, and, the fame of the great Baron van Sweiten and

his magnificent medical school having reached the innkeeper at Graz, to Vienna young Leopold Auenbrugger was sent.

Young Auenbrugger pursued his medical studies, if not with distinction, at least with the grave, thorough habit which was always his. When he had graduated, he was made resident physician and afterwards, in 1751, at the age of twenty-nine, physician-in-chief to the Hospital of the Holy Trinity. Three years later he married, wisely, a lady with a handsome dowry. Thus he settled down to a quiet *gemütlich* existence, comfortable at home, happy to be a citizen of this thriving capital, proud of his association with the great Baron, secure by his industry in his hospital position. The old lantern he used to light his footsteps, when called to visit a patient at night, through the dark streets with their high houses, is still preserved. He had his room isolated from the rest of his household, and installed a bell over his own bed which woke only him when a nocturnal messenger came from a house of suffering. He played his flute, liked music, and even began to consider writing an operetta.



Leopold Auenbrugger. He was too busy to compose operas for the Empress.

In the midst of this happy existence an idea came to him. It must have been, from the evidence he gives us in the preface of his work, about the time of his marriage. The idea, stated in the baldest possible terms by himself in the first sentence of that little book which made him famous, is:

"The chest of a healthy person, when struck, makes a sound."

This, perhaps, does not seem like much to you. But remember that in those days the diagnosis of conditions within the chest was a blank sheet of paper. People died of chest diseases, and all sorts of things were found at autopsy — solid lungs when the lungs should be filled with air, cavities in the lungs, great collections of pus and blood, enormous dilatations of the heart, swellings of the great blood-vessels, aneurysms. And yet all these things went on during the life of the patient and were unsuspected by the physician. That rigid, bony box of the thorax held its secrets. No one could see through it or feel through it. The abdomen, now, was different. If a tumour began to grow there, it could be seen or felt pushing its way up and obtruding itself under the lax abdominal walls. But not so the chest. The ribs kept it rigid. One could see nothing. Well might Baglivius, the great Italian physician, exclaim twenty-five years before Auenbrugger's birth: *"O, quantum difficile est diagnoscere morbus pulmonum* (Oh, how difficult it is to diagnose the diseases of the lungs)!"

So when Auenbrugger found that a healthy chest would make a sound when struck by the fingers, a flood of memories came to him. First, the fruits of his medical studies under Baron van Sweiten. The Baron, whatever faults he had, did insist on having students examine and question actual patients, and if those patients died, having their bodies opened after death in order that it might be proved what conditions actually existed. This practice Auenbrugger also carried out at the Hospital of the Holy Trinity. In this way he would often see chests full of a watery effusion after death. It must have been there during life. If so, it could have been removed by a trocar. Thus lives might be saved if only a man knew how to tell where the fluid was.

Then another idea — he was a musician. The lungs were full of air. They gave off a certain kind of note. The more air, the lower the note. Fluid in the chest would displace air, so the note would be different — higher in pitch and flat.

Then, finally, another idea. He remembered the inn at Graz. He

remembered his father striking the wine-casks to see how much wine was left in one. Above the level of the wine was air — the note was musical and low. At the level of the wine the note became flat — and high in pitch. The wine-cask was much like a chest. It was round and rigid, you could not see through it, but by striking it you could tell where the wine was. The wine was much like the watery effusions in the chests he puzzled over. The air in the cask was much like the lungs.

Fortified with these ideas, Auenbrugger began to examine patients in his hospital. He found many things — that " the sound elicited from a healthy chest over the lungs resembles the stifled sound of a drum covered with a thick woollen cloth "; that when the space occupied by the heart is struck, a " fleshy " sound is produced, like that of tapping the fleshy part of the leg; that, in his own words, if a naturally " sonorous part of the chest appears, on percussion, to yield only a sound like that of a fleshy limb when struck, disease exists in that part."

Thus he was able to tell when fluid was in the chest. He proved it by withdrawing the fluid or at autopsy. Besides he could tell when the lung itself was solid.

Then he found out about cavities. Here, perhaps, he remembered seeing his mother in the inn at Graz tapping a plate with her fingernail to see if it were cracked. The sound plate gave a sound ring. The cracked plate gave a cracked sound. We still say " cracked-pot resonance " for the description of the percussion note over cavities in the lung.

In 1761 Auenbrugger published his little book *Inventum Novum, ex percussione thoracis,* etc. — *The New Invention, which enables the physician from the percussion of the human chest to detect the diseases hidden within.* It is one of the great books in the history of medicine. It inaugurated a new era.

Your doctor still uses the " new invention " of Auenbrugger, although not exactly as he used it. He tapped his finger directly on the chest wall. Your doctor probably puts the finger of one hand down and taps this finger with a finger of the other hand. The sound elicited in this way is a little clearer, but the principle is the same.

Auenbrugger's after life is one of calm, eventless routine. Nobody paid any attention to the new invention. No one adopted it. No one used it but himself. The great Baron van Sweiten, to whom he refers with every mark of servility in his preface, did not mention it in his great

treatises on medicine, two of which appeared after the publication of his pupil's modest little volume. No one seems to have adopted it until Maximilian Stoll became Professor of Medicine in Vienna about 1776. He used it extensively. He proved that Auenbrugger was right — that fluid could be detected in the chest during life and evacuated.

Meanwhile Auenbrugger lived on quietly and industriously. He had a large practice. He cultivated the South German amenities — poetry and music. The Empress herself took some notice of him. He was made an "*Edler*," a knight. "Edler von Auenbrugg" is engraved under his portrait in his official biography. For his Empress he composed the libretto of an operetta, *Der Rauchfangkehrer* (*The Chimney Sweep*). It must have been pleasing to Her Highness, because report hath it that she requested him to try his hand at another. But he replied bluntly that he had more important things to do. This may refer to certain political jobberies he undertook for the Empress.

He had steeled himself to opposition. "I have not been unconscious of the dangers I must encounter," he wrote in the preface to his little masterpiece, "since it has always been the fate of those who have illustrated or improved the arts and sciences by their discoveries to be beset by envy, malice, hatred, detraction, and calumny." But not neglect. He does not mention that. Did it irk him? If so, we have no hint. But he knew his own worth. "What I have written I have proved again and again, by the testimony of my own senses, and amid laborious and tedious exertions." There is a serene certainty about that. He must have been happy when Professor Stoll took his method up. Stoll taught it to a French doctor, Corvisart. I hope he lived long enough — there is some confusion about the dates — to see a copy of the translation into French of his book that the great Corvisart made in 1808. For Corvisart was physician to the Emperor, and the next actor on our stage is none other than the glittering Napoleon Bonaparte himself.

Napoleon, indeed, appears, but in no heroic role. It is Napoleon in undress. His sword is not rattling in his scabbard. His asthma is rattling in his bronchial tubes. Napoleon has a cold.

He has had a cold for some time. His physicians call it "*gale répercutée*," or the internal itch (literally, the itch struck in). He has been variously treated until all the physicians are scared of him — he is a testy little man. And the cold gets no better. Perhaps it is peri-pneumony. The thought worries the victor of Lodi. He has a great many important

matters on hand — let's see, there is Russia and that old fool the Austrian chancellor, and — why can't these doctors get him well of this accursed wheezing? This would be a particularly inconvenient time to die.

When he voices these sentiments to one of his attendants, the name of Dr. Corvisart is mentioned. This Corvisart, it appears, has a new method for determining diseases of the lungs.

"A new method? What is the new method?"

Dr. Jean Nicolas Corvisart. He scolded Napoleon.

"Well, that is more or less a secret. But he does not just look at the tongue and nod wisely. He taps on the chest with his fingers. He has translated a book about it and made many converts."

"Send for him. Send for him." At all events no harm could result.

So Jean Nicolas Corvisart enters the presence of Napoleon Bonaparte. He explains this method of percussion. The Emperor, always interested in the new and the ingenious, grasps the idea. Corvisart practises it on his distinguished patient. He rejects the idea of the *"gale répercutée."* He changes the treatment. Napoleon recovers. It is not his bad luck to

die at an inconvenient time. His luck holds even in that — he is to die when it will make no possible difference to anyone.

But Napoleon is grateful.

He makes Corvisart his personal physician.

The consequences of this appointment were several. First, and most important, Corvisart dominated French medicine long enough to popularize percussion. Diseases of the chest and their diagnosis became a favourite topic for French physicians.

Corvisart became not only Napoleon's personal physician, but also a very intimate adviser. The story goes that on the occasion of the birth of Napoleon's son, the King of Rome, he undertook to lecture his Imperial benefactor.

Every obstetrician, I suppose, has to listen to the expansive self-adulation of some egotistical father when his first son and heir is born. It is a tedious business — the poor doctor yawning stupidly in the dawn, while the pompous little fellow struts up and down enlarging on his own importance and the quality of the claret he has set out. Think what it must have been to listen to Napoleon Bonaparte. Corvisart finally reached the end of his endurance. He could stand no more of it.

"Sire," he cautioned his Imperial patron, "this prince must crown all your wishes! Recall your career; in less than ten years a simple officer of artillery, then Captain, General of brigade, General-in-chief, First Consul, Emperor, spouse of an Archduchess of Austria, father of a prince. Having reached so dizzy a height of fortune, rarely attained by any mortal, I beg of Your Majesty to stop! Fortune may turn; you may yet fall."

"You speak like a peasant," replied Napoleon, and walked out of the room — to Leipzig and to Elba.

During those years when the gun-carriages were rattling over Europe, a thin wraith of a young medical student came up to Paris to complete his course in medicine. He was a Breton, René Théophile Hyacinthe Laennec. He was born of a tuberculous mother and himself was to die of tuberculosis, after dragging himself through a long life of invalidism. Attenuated to an incredible degree, we are told he was, by those who knew him in the flesh; barely five feet three in height. So thin, he once said jestingly, that he would hardly cast a shadow. Yet, in spite of all these physical handicaps, he did some of the most important work ever done in the world.

He was a child of the Revolution, born in 1781. He was a regimental surgeon in the armies of the Republic. He saw heads fall in the basket beneath the guillotine.

He first studied medicine in Nantes. When he came to Paris, he chose the teaching of Corvisart. He received prizes for proficiency. He published papers on medical subjects. He became a teacher. He acquired patients among the new and the old nobility.

And in the meantime the Revolution burned out in the fire of its own excesses. General Bonaparte carried the Alps. The First Consul led an army into Austria. The Emperor was crowned. All Europe was at the feet of France. The Emperor divorced the widow Beauharnais and espoused the daughter of the Habsburgs. The King of Rome was born. The Emperor was defeated at Leipzig. He returned from Elba. The old guard did not surrender. The cavalry crashed into the sunken road of Ohain. The *Northumberland* took their Emperor to St. Helena. Cancer began to grow in his stomach. And all this time the incredibly attenuated young Laennec pondered over the problems of disease.

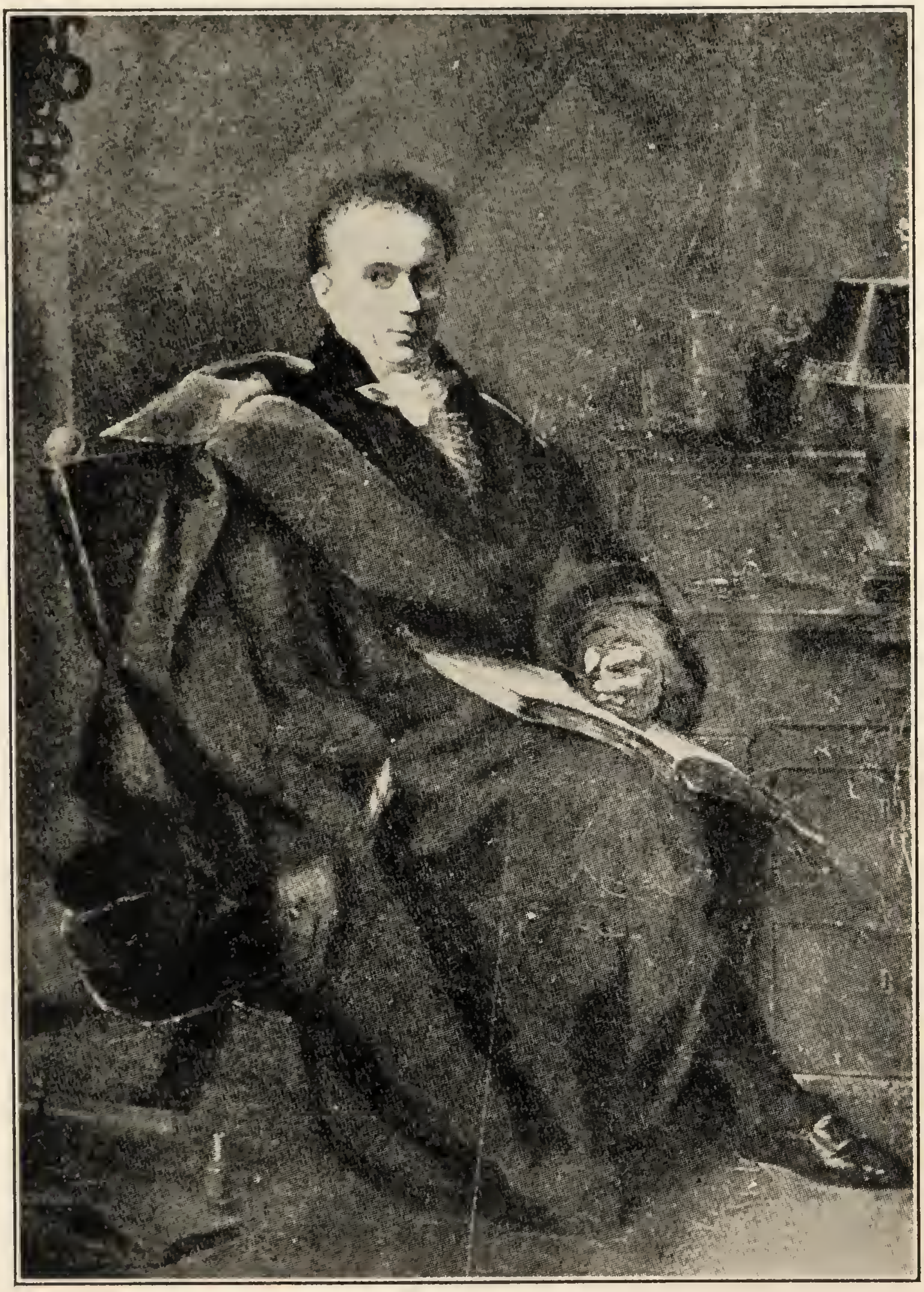
He was appointed physician to the Necker Hospital. Two-thirds of the patients in his hospital wards were consumptives. The veterans of the Grand Army had returned from the hardships and exposures of twenty campaigns riddled with tuberculosis. Many of them were in Laennec's ward. His close friend Dr. Bayle had described the tubercle and written a work on phthisis (tuberculosis of the lungs).

What could be more natural than that he should be interested in tuberculosis? His mother had died of it, he suspected it in himself, his wards were filled with it. His teacher, Corvisart, had naturally made him read Auenbrugger's little book on percussion and master the method. It was especially applicable to tuberculosis. On tuberculosis he thought and brooded and worked.

In the course of his work he found many conditions which went unsuspected during life — which the percussion method of Auenbrugger was inadequate to reveal. Was there anything else? He pondered this often. He studied the features of his patients carefully. He knew many things about them in the most intimate detail. One day, for instance, when he was walking below the window of one of the wards, a patient spat out the window. The sputum lit on Laennec's hat. His companion uttered an exclamation of disgust. Laennec removed the hat,

looked observingly at the sputum, and, shrugging good-naturedly, said: "Poor fellow, let him alone. He will be dead in six months."

A man who knew the details of his subject like that must often have longed for some more certain way to make his diagnoses more exact.



Laennec.

Percussion he had mastered. It would show a solidification of the lung. Sometimes it would show a cavity — when that cracked-pot sound Auenbrugger first heard in the pantry of the inn at Graz was present. But at other times cavities would be found at autopsy when no sign or suspicion of them had appeared in life.

Then the heart. There was a puzzling field. Could those excrescences on the valves so often seen in the dead-house ever be predicted in the ward? Did the heart make any sounds when it contracted or dilated?

When that idea of listening came to him we do not know. He must have been aware of certain crude forms of diagnosis by listening. He was a student of Hippocrates — we know that. And Hippocrates had listened to the chest. When there is fluid within and the patient shakes himself, a splash can be heard. Hippocrates had described that splash: it is known as "Hippocratic succussion." Many a patient today comes into a clinic and in answer to the question: "Why do you come here," replies: "When I walk, I splash."

Then his teacher, Corvisart, while he never actually put his ear down to the chest, had said in some of his lectures that he heard the heart-sounds when listening close to the chest. Dr. Bayle had tried listening with his ear immediately to the chest. A Dr. Double had also listened to the chest and in 1817 published a book in which he advocated placing the ear against the chest. Long afterwards he claimed to be the originator of auscultation.

In point of fact, no discovery was ever made which more clearly belongs to the man whose name is associated with it than Laennec's discovery of the stethoscope. None of his predecessors advocated the use of a tube — the stethoscope — which would augment and particularize the sounds of the lungs and heart. Nor did any of them prove comparatively by autopsy what the sounds meant. In Laennec a fortunate invention found a man prepared by years of research, with an uncanny knowledge of the diseases such an instrument could reveal during life.

"In 1816," he wrote, "I was consulted by a young woman with symptoms of a diseased heart, in whose case percussion gave no information because she was too fat." Nor could he bring himself, on account of his patient's age and sex, to place his ear directly to her chest wall. The first, faint twitter of Victorian modesty appears in this admission. Had he lived in 1919 instead of 1819 he could have put his ear anywhere and not a qualm would have troubled him. The stethoscope would never have been invented.

But there was the patient, and there was Dr. Laennec, and there was the modesty. He knew she had heart disease, and he would like to listen to that heart. What to do?

He took a walk. He had accepted the appointment at the Necker Hospital because it had a fine garden, and this offered him, with his

not very vigorous health, an opportunity for exercise. He walked in the garden. His walk continued. He walked in the gardens of the Louvre, we are told, and there around a pile of litter a crowd of little children played. One of their games was with a wooden plank, perhaps

Laennec making a ward visit in the Necker Hospital, Paris, 1816. The stethoscope may be seen in his left hand. (From a painting in the Sorbonne)

a seesaw; one child would get down with ear pressed against one end of the plank while another scratched with a pin or tapped on the other end. That a person could hear the scratch of a pin that far away delighted the imagination of the children.

"I happened to recollect a simple fact in acoustics — the great dis-

tinctness with which we hear the scratch of a pin at one end of a piece of wood on applying our ear to the other."

He went back to the hospital. He rolled a quire of paper into a kind of cylinder and applied one end of it to the region of his fat patient's heart and the other to his ear and " was not a little surprised and pleased to find that I could thereby perceive the action of the heart in a manner much more clear and distinct than I had ever been able to do by the immediate application of the ear."

It must have been a thrilling moment. To have been the first to hear the sounds of the living human heart and the sounds of the living human lung. Helmholtz describes something of the same emotions when, with his ophthalmoscope, he was the first to see the inside of a living human eye. Columbus discerning the flickering light upon the little island, Keats looking into Chapman's Homer, Rockefeller having salted away his first million — they are all compact of the same ecstasy.

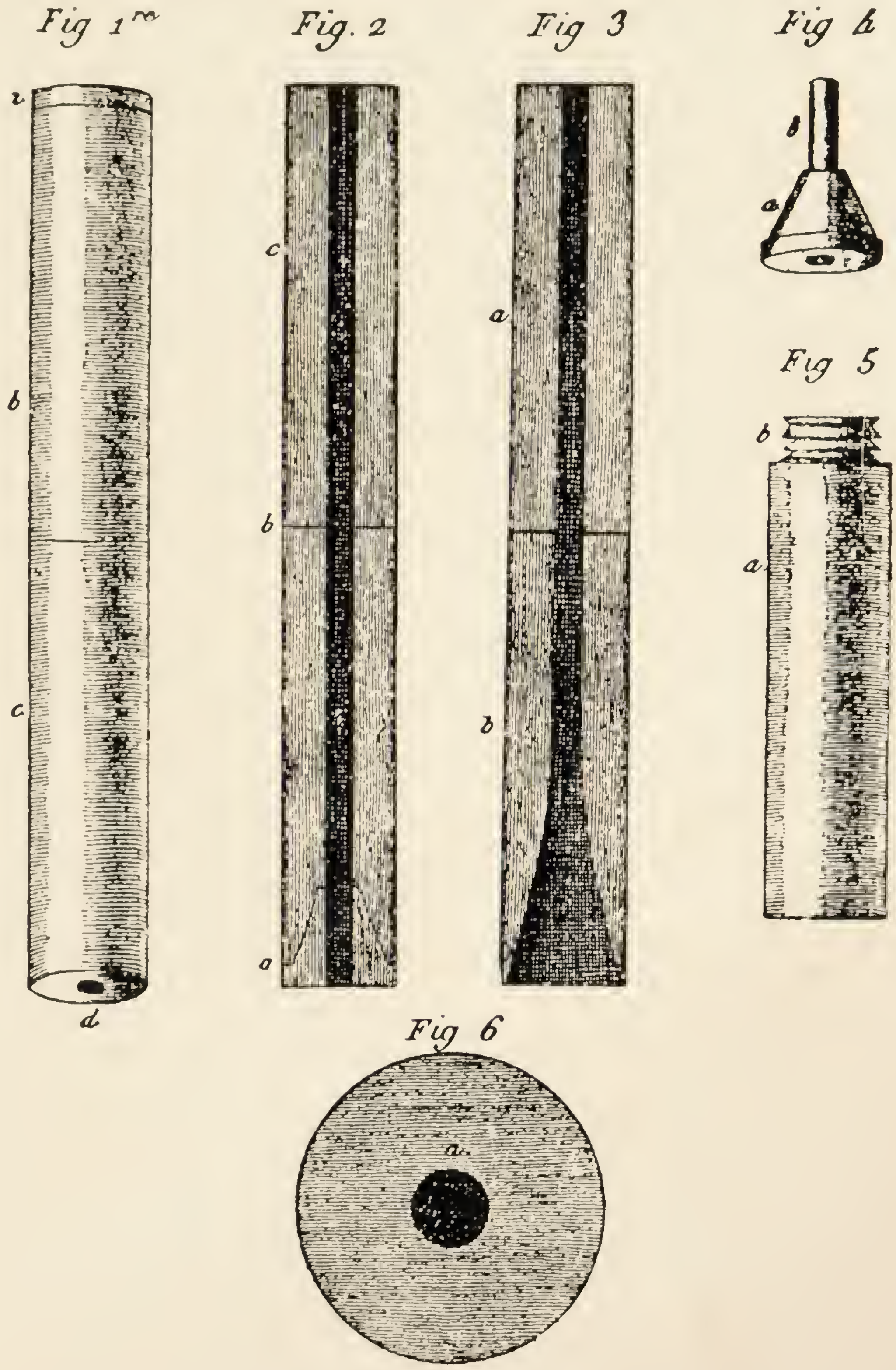
And then to go from patient to patient in the ward and compare the sounds *their* hearts made with the diseased one's. And to listen to the multitudinous sounds which came from the lungs of that ward of tuberculosis patients. How did he ever straighten them out at all, the poor young medical student who is just beginning physical diagnosis wants to know. Here at least was the work of a lifetime.

" With this conviction I forthwith commenced at the Hospital Necker a series of observations from which I have been able to deduce a set of new signs of diseases of the chest."

He tried his method out under many conditions. He was about this time called into consultation with his rival Dr. Broussais, an opinionated bully several years older than Laennec. On this particular patient Broussais made the diagnosis of pneumonia. Laennec, who by then had improved his paper cylinder, disagreed. He called the disease empyema, or a collection of pus in the pleural cavity following pneumonia. There is probably no disease more frequently mistaken for tuberculosis or pneumonia. Laennec, with the stethoscope, had a great advantage over Broussais because if Broussais employed only percussion, both pneumonia and empyema would produce a flat sound; but when one listens with the stethoscope over a pneumonia the breath-sounds are loud and bronchial, while over the empyema there are no breath-sounds at all.

Then there is another sound just above the level of the pus in empyema made when the patient speaks. Laennec had discovered it and

called it "ægophony." "It is," he says, "a trembling or bleating sound like the voice of a goat." It is also, to quote his graphic illustrations again, like "the nasal intonations of the juggler speaking in the character of Punch." Ægophony was also present in this case.



Laennec's first stethoscope.

Thus Laennec stood for empyema, Broussais for pneumonia. The only way to settle it was to stick a hollow needle, or trocar, in between the patient's ribs. This was finally done and pus discovered. Laennec was right. Thus on the field of battle he proved his new device. He made a lifelong enemy of Broussais, however. He recounted the incident in his book with names disguised, but Broussais recognized it.

Laennec and Broussais managed to develop one of the most famous medical quarrels in history. Both were exceptionally bitter and venomous. Both were oracular and oratorical. Broussais believed that all diseases were due to irritation. Oliver Wendell Holmes, a medical student in Paris at a slightly later date, described Broussais thus:

"The way in which that knotty-featured, savage old man would bring out the word irritation — with rattling and rolling and reduplication of the resonant letter r — might have taught a lesson in articulation to Salvini."

The rolling of paper cylinders became a bore, so Laennec had a wooden cylinder turned out on a lathe. The binaural stethoscope (with two ear-pieces) and the rubber tubing, with which every patient is now familiar, came much later. The name "stethoscope" was Laennec's own invention. His physician uncle had suggested thoracoscope, but Laennec objected that this was partly Latin, partly Greek, and he made it all Greek by combining *στῆθος* (the breast) and *σκοπ-εῖν* (to examine).

But to the end of his life he himself called it a baton. He had lived in the days when every private had a marshal's baton in his knapsack. This was his marshal's baton in the army of science.

Distinguished patients helped to enlarge the reputation of the instrument. Madame de Chateaubriand had developed a cough, fever, and hæmorrhage — spitting of blood. It was called tuberculosis of the lungs. She consulted Laennec. He was unable to find another new sign he had discovered — pectoriloquy. He therefore rejected the diagnosis of tuberculosis. The lady recovered. His fame spread. He had disproved the diagnosis of the faculty with his baton.

Chateaubriand himself had consulted him some time before. He thought he had an aneurysm. Laennec reassured him.

Madame de Staël had the dropsy. Laennec was called in. He thought he detected fluid in the chest. But the autopsy found none. It was suggested that sufficient time had elapsed for its absorption. He learned from his mistakes as well as from his successes.

In 1819 his book *De l'auscultation médiate* was published. With each copy was sold one of the wooden stethoscopes. Two editions were exhausted.

In 1822 he was made Professor and Royal Lecturer at the College of France.

In 1823 he began to prepare an enlarged edition of his work, which was published in 1826.

In 1825 his health, long unstable, broke down. He made the last of his many trips to his native Brittany. He was sounded by physicians with his own discovery, the stethoscope. The diagnosis was in doubt. It was probably tuberculosis, the disease he had studied so thoroughly. In 1826 he died.

The use of the stethoscope has steadily increased until today it is indispensable. In the early days it met with both opposition and ridicule. The young physicians who somewhat ostentatiously carried their stethoscopes around in their hats were favoured with some wry smiles by their elder colleagues. Dr. Benjamin Ward Richardson tells us that when he was beginning practice, he met in consultation one of these ancients, who claimed that he "did very well without the tube" and inquired airily whether one could "expect to hear the grass grow through it."

But this sort of thing is expected. Opponents spread the gospel faster than disciples.

These methods — percussion and auscultation — laid the foundation for the precise diagnosis of the presence of disease in the living patient. Hippocrates and Sydenham, and many others, had described the course, the natural history, of diseases — and that was fundamental. But it did not necessarily record the signs made by the body in the different stages.

The modern method of procedure in diagnosis is first to record the history. Ask the patient to tell the story of the disease. How inaccurate this may be can be imagined by comparing the stories of "Have I told you about my operation?" from the patient and the same narrative as recounted by an unsympathetic and waspish member of the patient's family.

Pain, for instance, is a symptom. Only the patient is aware of it. There is no way for the physician to measure pain. There is no way for him even to be sure the patient has a pain. Everything he knows about the pain must come from the lips of the patient.

Therefore any methods we have which can objectively check up on the presence of disease and which are uninfluenced by the patient's state of mind are extremely valuable. Medicine began to advance as such methods were multiplied.

2. *What Medicine Learned from an Old Market-woman*

In 1834 a medical student from Corsica, named Renucci, was studying in Paris.

He was in a most unhappy frame of mind because he doubted the wisdom of his teachers. And if one begins to doubt authority from above, even on a single point, the whole fairylike mansion of confidence is demolished.

Jolly old Baron Alibert.

But Renucci had reasons for his doubt. It was this talk about the *psora* or the *gale* — in fact, the itch.

It will be remembered that when we saw, in an earlier part of this chapter, the great Emperor of the French himself stretched on his sick-bed, the physicians called his malady "*gale répercutée*" — or the "itch struck in," or the "internal itch." This was simply using the fashionable

language of the day, because it was the idea of the time that half the diseases in the world were forms of the itch.

Of course nowadays it would be insulting to tell a member of the "uppah classes" that he had the itch. You would have to take him in a room apart and whisper it to him and make a joke of it. And to call a king's or an emperor's malady the "itch" would be worth a court physician's place. The itch results from not very scrupulous cleanliness, according to our ideas. We see it often enough — we call it *scabies* — but mostly in charity patients.

It was far otherwise in the early nineteenth century. Itch was a fashionable, a court, disease. They had it then just as you now have high blood-pressure or influenza, or inferiority complexes. There were not as many bathtubs then as now, nor scrub-brushes, though no one even whispered that itch could be due to lack of personal cleanliness. In fact, nobody knew what did cause it.

It appeared on the skin, especially on the hands between the fingers, just as it does now. But some doctor spun a beautiful theory that when a patient had some internal malady like dropsy or fever or liver disease, it was the itch which had worked its way inside the body — the *gale répercutée.* This, of course, was not so terribly far-fetched as it sounds. There are analogies for it in other parts of the field of disease. There is syphilis, for instance, which appears on the skin and also invades internal organs. There is tuberculosis of the skin, caused by exactly the same bacillus which caused tuberculosis of the lungs, and of the bones, and of the peritoneum.

But in the period of the craze of the itch fad there were several differences. First, no one knew the cause of the itch even on the skin. Thus, since we do know the cause of syphilis and of tuberculosis and can identify the same organism in the lesions in the skin as in the internal organs, our ideas are based on sounder observation than theirs. Then, in the itch-fad days speculation ran riot and was not even recognized as speculation: it was given out solemnly as authority.

One of the cardinal tenets of the doctrine of homœopathy as promulgated by its founder, Hahnemann, was that "the large majority of chronic diseases were due to 'the actual itch.'" "It has cost me twelve years of study and research," he wrote, "to trace out the source of this incredible number of chronic affections." Later — within a very short while — his foremost disciples repudiated this part of the doctrine.

He had plenty of good company in his error, however, in the days of his prime. All the best clinicians, especially of France, were convinced of the itch theory.

But F. Renucci, the Corsican, was not satisfied. He listened respectfully on the benches while the professors showed cases of dropsy as examples of *gale répercutée,* and of phthisis as *gale répercutée,* and of jaundice as *gale répercutée.* And then they went on to say they didn't know what *gale* was, exactly. And his Professor of Skin Diseases, Alibert, " jolly old Baron Alibert," whom Oliver Wendell Holmes remembered so well " in his broad-brimmed hat worn a little jauntily on one side, calling out to the students in the courtyard of the Hospital St. Louis — ' Enfans de la méthode naturelle, êtes-vous tous ici ? ' " — Alibert used to show cases of the itch on the skin between the fingers. And even the Baron Alibert did not know the cause of this condition. Alibert had an enormous chart, a picture of a tree, which he afterwards printed as the frontispiece of his book. It was a family tree of all skin diseases. It was the basis of his method — the natural method. And the jolly old Baron used to show cases and lecture to his " infants " on all those subtle relationships.

But the thing that kept going through F. Renucci's mind was that the Baron himself did not know what the cause of the itch was. He repeatedly said so. Even the itch — a simple thing like that.

And this was disconcerting. Because how could a man build up a " natural method " of relationships in skin-diseases if he did not know the cause of any of them ? And how could the other professors know that all of these internal diseases were due to the itch when they did not even know the cause of the itch on the skin ?

For F. Renucci knew the cause of the itch. At least, he thought he did. It seemed so simple and was such common knowledge among common people in his country that he doubted what he knew was true when all these glorious and grand people in Paris confessed to ignorance of it.

So F. Renucci was in the toils of doubt and of a dilemma.

He braved the lion and sought out Doctor Baron Jean Louis Alibert.

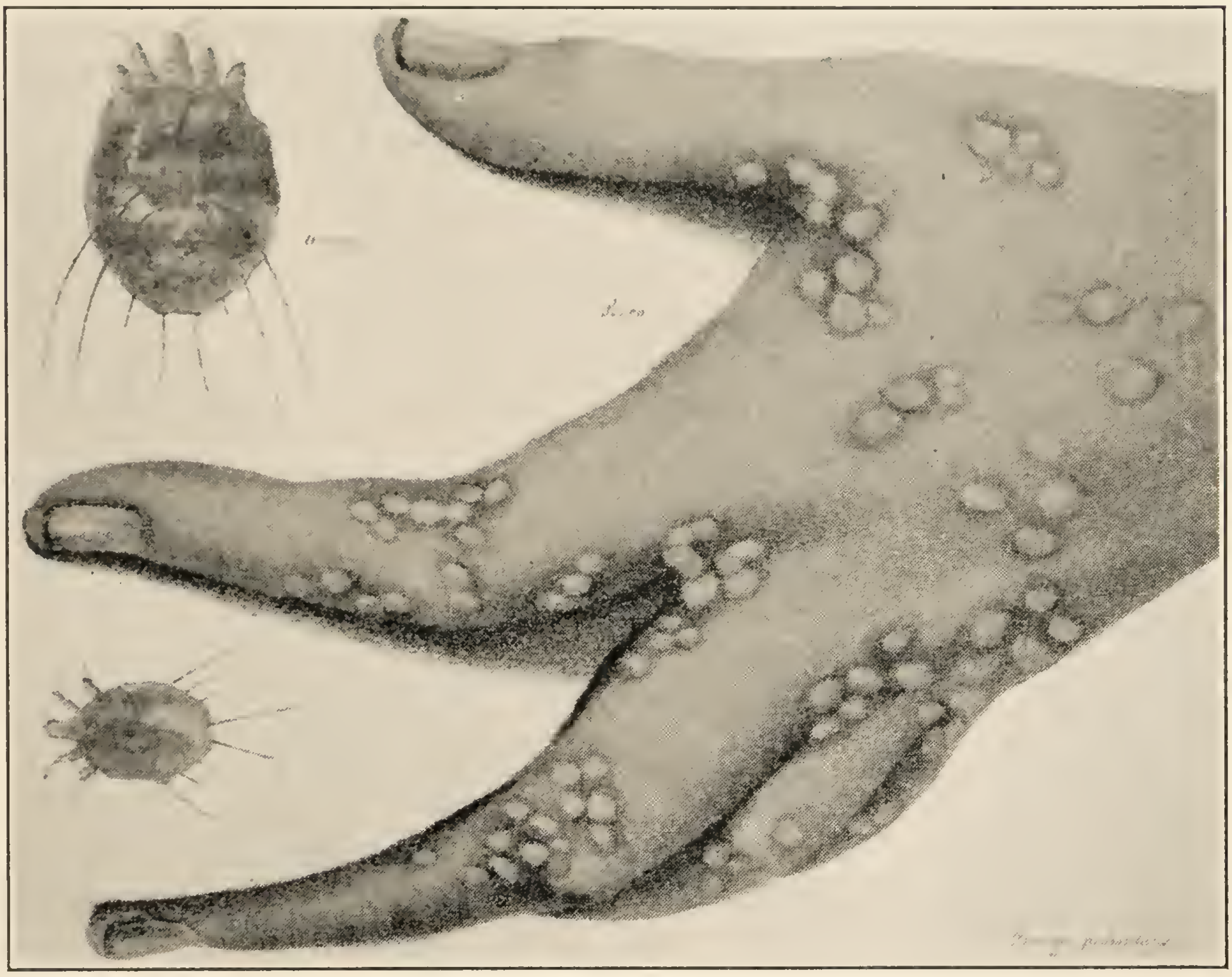
" Monsieur le Baron," he stammered, " may I, a humble student of your distinguished lectures, communicate a theory to you ? "

The jolly old Baron looked at him quizzically and laughed. " To be sure, to be sure, my little one," he answered.

"It is about the itch," began the Corsican student; "you tell us you do not know the cause of the itch."

"Ah, yes," agreed the Baron, shaking his head — "that itch, eh? There is much to be said."

"But," interrupted the student, "I know the cause of the itch."



The itch. The itch-mite is pictured in the upper left-hand corner, and again in the space between the index and the second finger. The hand shows the appearance of the itch on the skin. (From Alibert's Monograph des dermatoses)

"M-m-m — so — you know the cause of the itch, eh?" the Baron observed.

"All the old women in my country know the cause of the itch," answered the student. "My country is Corsica, sir. See here! I used to see the old market-women sitting in their stalls pricking at their hands with a needle. I watched them day after day, sir. I was interested. Finally I asked one of them what she was doing. And she laughed and told me she was curing the itch."

"So, Monsieur le Baron, I sat by her to learn her secret. And on her hands was the itch — the veritable itch. Just as you have shown us at the Hospital St. Louis. On the skin of the hands — especially between

the fingers, where the skin is tender and thin. And there is the small red spot and the pustule and the little scab just as you have so beautifully described and painted it for us, Monsieur le Baron."

"Yes, and then what?" demanded the Baron, darkly.

"Then this old woman showed me, sir, how she could take a fine needle and she would prick the skin just behind the little red spot and she would spear a little red spider of an insect, sir. And when she had removed this insect, the itching would go away from the particular spot. So they think in my country, Monsieur le Baron, that this insect is the cause of the itch."

"Now, see here, my infant," said the Baron, a little testily, "I have made a fool of myself that way once before. There was a pharmacist here in the hospital — long ago — named Gale, and he came to me and said he wished to do a research. Eh?

"'Well,' said I, 'do a research, my friend, and do it on the itch, since your name gives you every right to do so.'

"So he did it, and you know he found just what you say. He found an insect. Oh, I have his paper here! Let me read you. See! See! Read before the Paris Faculty of Medicine in 1812, twenty-two years ago. See what he says: 'I placed under the microscope in a watch-glass a drop of distilled water in which I had previously satisfied myself there was no nimble tiny animal. I added to the water with the point of a lancet the fluid extracted from a vesico-papular lesion of scabies. I was agreeably surprised to find a living insect, which moved with agility in trying to escape from the watch-glass. Monsieur Patrix made a very good drawing of this on the spot.'"

The Baron looked at young M. Renucci and protruded his under lip.

"But, do you know — after all that was done — no one else ever found that itch-mite?" he continued. "And then they proved that the mite this Gale found was a cheese-mite — found in cheese. Eh? I have never been so humiliated. No, I am not likely to commit the same folly again, sir."

The poor Corsican was not entirely dashed.

"It is very upsetting," he agreed.

"It upset me," said the Baron.

"But did they not accuse Gale of trickery and dishonesty?" asked Renucci.

"They accused him of everything," said the Baron, "and me, too. They accused me, Jean Louis Alibert, of collusion — of trickery. Said Gale and I had dropped the cheese-mite into the accursed water."

"But, sir, I think I can prove that there is no trickery about it. I think I can teach you to pull out the itch-mite yourself."

"Eh? — You will, eh?"

"Oh, you can learn to do it very easily, sir."

"As easily as an old market-woman," laughed the Baron, and clapped the young fellow on the shoulder.

"The old market-women," the boy continued with his story, "think that the insect hides in clothes and bedding and burrows its way into the skin while one is asleep, in order to suck human blood."

"Eh? Now — no, it cannot be," pronounced his professor.

"Of course it is possible, Monsieur le Baron, that the disease here in Paris is not the same as in my country of Corsica."

"It is very likely indeed — if what you say is true," grunted the Baron, shortly. He was evidently not too pleased thus to be instructed by one of his pupils. "In fact, it is almost certain."

"But I believe," continued this persistent young man, "that if it were true, and if the cases of itch you show in your clinic are really due to this insect — I believe I could spear the thing with a needle as the old market-women taught me to do."

M. le Baron Alibert simply stared at his interlocutor when this proposal was made.

"So if Monsieur le Baron would graciously give me the opportunity to experiment, perhaps I could show Monsieur le Baron this so interesting little insect."

However, the Baron would promise nothing. But then the more he reflected, the more curious he got. He would like to see the Corsican itch insect hoisted out on the point of a needle. And it would be quite a feather in his cap. It would set all Paris talking. All these pompous asses who were talking about the internal itch would have something to prove for themselves. Perhaps Gale had been right. Perhaps the Baron's rivals had laughed too soon.

At the thought of his colleagues' discomfiture the Baron smiled. His equanimity returned. Come, it would do no harm to let the lad try.

So down into the arena he calls the young Corsican the next time he has a case of itch to show. It is August 13, 1834.

"Everyone has agreed this case is the authentic itch — there between the fingers. Now let us find out if this is the Corsican itch."

The Baron is quite jovial about it.

The medical student takes the needle and bends over the patient's hand. He pricks the skin once or twice. The patient winces and tries to draw away. But no, it will not be allowed. He starts in on a fresh place. Then he pulls out the needle. On the end is a little red speck.

Photo-micrograph of itch-mite made in a modern laboratory.

They bend over the needle, the professor and his infants. Sure enough! That speck, when you look closely, has little hairlike legs. They bring up a magnifying glass. No doubt about it. It is some sort of an animalcule that the young Corsican student has speared on the end of his needle.

Baron Alibert described the event thus:

"On the 13th of August 1834 my pupil, Monsieur François Renucci,

who was with me when I was busy in the dispensary, in the presence of numerous students, found the insect so eagerly sought for on the hand of a young woman who was covered with the pustules of scabies. He at once removed it onto his fingernail by means of a pin and showed it to me. During the same session Monsieur Renucci repeated his searches several times and always with the same success."

They try it on other patients. The Baron himself learns to spear the itch insects. Then for purposes of comparison they bring up patients with diseases of the skin that are not the itch. "Let us try," suggests the Baron, "if we can find the insect there also. Perhaps the insect is a normal inhabitant of the skin." But no, they cannot be found in these other kinds of diseases — only in the true, the authentic itch.

The Baron tells his colleagues about it. He demands that they find the itch insect in their cases of *gale répercutée*. He pokes fun at them gently, but persistently. He jokes them out of their delusion about so many chronic diseases being due to the internal itch.

The Baron is somewhat nettled to find that the whole thing has been discovered before. By a German from Hamburg, named Wichmann. But this has frequently happened in the history of medicine. "All my best thoughts were stolen by the ancients," said Emerson. So it happens in medical science. A man makes a great discovery and then finds he was preceded by someone he had never heard of. Wichmann's book was published in 1786. It was called *The Cause of the Itch* (*Ätiologie der Krätze*).

Even before Wichmann, although Baron Alibert did not know it, an Italian savant, named Bonomo, wrote and published an open letter to that Francesco Redi who proved that maggots would not grow in meat if one kept the meat covered. The letter described the itch insect exactly as well as Renucci did. This is what Bonomo wrote to Redi in 1687:

"Having frequently observed that the poor women when their children are troubled with the itch do with the point of a pin pull out of the scabby skin little bladders of water, and crack them like fleas upon their nails, and that the scabby slaves in the Bagno at Leghorn do often practice this mutual kindness upon each other, it came into my mind to examine what these bladders might really be.

"I quickly found an itchy person, and asking him where he felt the greatest and most acute itching, he pointed to a great many pustules

not yet scabb'd over, of which, picking out one with a very fine needle and squeezing from it a thin water, I took out a very small white globule, scarcely discernible; observing this with a microscope I found it to be a very minute living creature, in shape resembling a tortoise."

So far as priority goes, then, the award must be made to Bonomo. But a discovery is valuable not just because it is made, but because it becomes known. When Renucci, with Alibert behind him, announced the technique of identifying the itch-mite, the whole world soon knew it. Alibert's recognized position in the scientific world assured that. Soon the diagnosis of itch became certain instead of speculative.

If any doubts remained, they were set at rest twenty-three years later, when, in 1857, Erasmus Wilson proved that a live itch-mite placed on healthy skin would burrow in and produce a case of the itch in a person who did not previously have it. This was a step of great significance. It anticipated one of the four postulates of Koch. Koch demanded that before any germ could be announced as the cause of a disease four conditions should be satisfied. Not only must the germ constantly be found present in the disease, but it must be isolated outside the body, and *when introduced into a healthy body, must reproduce the disease.* This last postulate Wilson was able to establish for the itch-mite.[1]

The significance of the discovery of the itch-mite is fundamental. If one is to make a diagnosis, one must have some standards. The best standard is to know what causes the disease and to show it is present. The most uncertain is to say: "This disease looks and acts like other cases of the disease I have seen."

What does the itch look like? Well, these skin specialists can describe it as much as they want — its favourite location, its symptoms, its stages, all about it — but what it comes down to is that it is a little red spot on the skin. Now, here is a little red spot on the skin. Is it the itch or not? One doctor says yes, and another doctor says no. But if you have the cause of the itch, if you can see it and demonstrate it, if it is a little insect and you can pull it out of places in the skin, then you have a better method of telling whether the red spot on the skin is the itch than all the doctors. If it is the itch, the itch insect can be found. If it is not the itch, the itch insect is absent.

So with other diseases. In 1833 an interne at St. Bartholomew's Hospital in London found some round white masses in the muscles of a

[1] Koch's fourth postulate called for the isolation of the organism from the inoculated healthy body.

subject he was dissecting. He took them to Richard Owen, Professor of Comparative Anatomy, who put them under the microscope. They were little spiral worms. The professor called them *trichinæ*. Later it was discovered that they infected pigs and got into the human body through eating pork. Here was another disease which could certainly be differentiated from all its imitators by identifying the causative parasite.

Then Johann L. Schönlein, Professor of Medicine at Vienna, made another discovery about the skin. This was in 1839 — five years after Renucci had demonstrated the itch insect to Alibert. There is a queer disease of the scalp which Schönlein studied. It makes the hair fall out in spots and encrusts over the bald spot with a gray scab. It is called *favus*. Schönlein found in all his cases a fine vegetable fungus adhering to the hair, which he could see under the microscope.

Then this peculiar itching and blistering eruption you get between the toes, especially in summer and especially if you use the shower in the locker of your golf club. That was found to be due to a vegetable fungus and called "ringworm" by Tilbury Fox in 1862.

So, after Renucci, the identification of diseases due to minute animal and vegetable parasites went on apace.

3. *Urine Examination*

"You've come to the right shop," said the senior medical student to his Edinburghian cousin, "when you've come to London to put the final finish to your medical education."

His cousin smiled enigmatically, as Scotchmen will. He evidently thought they knew a few things at the University of Edinburgh in that year of 1828.

"Yes, sir, me hearty, you've come to the right shop, and you could be at no better place in all London than Guy's Hospital. There's new medicine being taught at Guy's — a whole new school of it. Oh, I know there's Abernethy and Laurence over at Barts,[1] but you'll find plenty, I warrant you, if you come along with me to Guy's."

They were walking along the narrow streets across the river from London itself. A fat old woman came by with an umbrella and an immense basket on her arm.

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[1] Saint Bartholomew's Hospital.

"Hi! You old guzzler," the London student laughed at her, giving her basket a pull as if he would take it away from her.

"Go along with you, you bage creature," replied the old dame, spiritedly lunging at him with her umbrella.

"Wha were yon?" asked the Scotchman, when they were out of hearing.

"Oh! That's Gamp — our Aunt Sarah — an old midwife hereabouts. She can drink you under the table any day in the week, me lad."

The Scotsman did not reply although he guessed to himself that the Londoner had forgotten he came from beyond the Tweed, where drinking is a vocation.

"Yes, Abernethy is a good sort," the Londoner continued; "he'll give you a rare lecture and keep you laughing — a rough dog. We can go there tomorrow. What a tongue he has in his head! A rich old fellow came to him one day — you should hear him tell the story. 'How shall I cure my gout?' says the rich man. 'Live on sixpence a day and earn it,' yells Abernethy at him.

"Never saw anybody get the better of him but once — and that a student. 'What would you do,' says Abernethy, 'if a man was brought to you with a broken leg?' 'Set it,' answers the student. 'Good — very good, you're a very pleasant, witty young man,' says Abernethy, as smooth as oil, 'and doubtless you can tell me what muscles of the body I should set in motion if I kicked you, as you deserve to be kicked, for your impertinence.' 'You would set in motion,' says the student, 'the flexors and extensors of my right arm, for I should immejiately knock you down.' And the great John Abernethy never replied a word. But here we are — "

And turning into a doorway, the Londoner brought his cousin into a pub filled with young men leaning back in their chairs with their feet on the tables, smoking long cigars and talking and chaffing each other.

"All Guy's men here," explained the Londoner. "We'd better have a glass of sherry and bitters before we go."

A rakish, dirty young man who was sitting near them at a table with another of the same general appearance glanced impudently at the stranger and, getting up, handed him a small round object.

"Have a biscuit?" he asked.

"Why, 'tis a patella," exclaimed the Scotchman, looking at it.

"Here, Ben, none of your waggishness — this gentleman is at Edinburgh University in the medical department and cannot be scared by a bone."

The dirty young man murmured an apology and went back to his table, where his companion greeted him with a loud laugh.

"Two chronic drunks — Ben Andrews and Bob Sawyer," explained the Londoner. "But come along — it's time to get into the wards, and little Bright is never late."

So, having paid for their sherries, they went out again and entered the gloomy doorway of Guy's Hospital.

"We go to Miriam ward," said the Londoner, and mingling with the train of other students, they went along the halls and up the steps until they stood outside the door of the ward.

"Here's Bright now," someone whispered, and a little, dandyish man walked briskly up, attended by some assistants. He was a handsome little fellow, dressed neatly in shorts and gaiters, with seals and fobs hanging from his pockets. He carried a large gold-headed cane, as all physicians of his time did. He was said to have the largest medical practice in London, and his affable manners and dignified composure made one easily believe it.

"I wish to show you some cases of dropsical effusion, gentlemen, today — of dropsy," he said, briskly. "This way, if you please." He walked to a bed where a white-faced little girl was lying, and drew back the covers.

"You notice, gentlemen, the swollen condition of the whole body. There is some sort of fluid everywhere, under the skin. The face is puffy, the legs are swollen. They pit when I press on them. The abdomen is enlarged. It is undoubtedly dropsy.

"Now, gentlemen, as is generally known, the usual cause ascribed as the origin of dropsy is a disease of the heart. When the venous circulation is sluggish, gentlemen, the blood accumulates and dropsy results.

"There is no doubt of the truth of that statement, gentlemen, but is that the only cause of dropsy?

"Here at Guy's we do not think it is, and nothing illustrates it better than this case we are now seeing. First let us investigate to see if there is anything wrong with the heart. For obviously if the little patient has dropsy, gentlemen, and the heart is normal, we must look elsewhere for the cause of the dropsy.

"Now, gentlemen, I will feel the patient's pulse, timing it by my watch, as we have lately been reminded to do by our Irish colleagues."

Pulling out one of his watches, he felt the pulse.

"I make it to be sixty to the minute, gentlemen, and quite regular. So that would indicate no great disturbance of the circulation. Now I am going to ask Mr. Addison here to listen to the heart with the new French instrument — the s — at — oh, stethoscope, that's it — the stethoscope — a hard word to say, gentlemen, but one I warrant you we must

Richard Bright, of "Bright's disease" fame.

learn. Invented in France, gentlemen, and Mr. Addison here has perfected himself in its use."

A tall, austere, forbidding young man came forward and, taking out a short, hollow stick of wood from his pocket, he put one end over the patient's chest and, leaning down, applied his ear to the other end. As he did so, Dr. Bright opened the head of his gold cane and applied it to his nose; it contained some sort of scent, for the condition of the ward and the sick patients was truly a trial to a sensitive olfactory membrane.

"The sounds of the heart are normal," announced Mr. Addison, resuming the erect position.

"Oh!" said the little man, closing his scent-box with a snap. "You hear that, gentlemen, Mr. Addison assures us the heart — at least the sounds of the heart — are normal. And so, I think, the pulse is. Now where shall we look for the cause of this dropsy?

"Here, gentlemen," he continued, holding up a glass. "Here is a specimen of this patient's urine, and I wish to show you some interesting facts we have found about this substance in such cases. Just hand me that candle and that spoon, will you, William?

"Now, gentlemen, I intend to pour some of this patient's urine in this spoon and boil it over this candle. Notice, first, that the urine in the glass is nearly clear. It has been somewhat scanty at first — that is early in her disease — there was a smoky, bloody appearance to it. But now it is fairly clear. But notice that when I boil it in the spoon here — see there — see those clouds — and flakes — there — see."

There was a great rustling and straining of necks in the crowd of students to see the coagulated urine in the spoon as Dr. Bright boiled it over his candle flame.

"Now, that is what we have found in these cases, gentlemen — a coagulation, an albuminous deposit form in the urine in such cases of dropsy.

"Now" — walking away from the patient, but not before giving her a little smile, he continued when he was out of ear-shot — "we have followed many of these cases to the dead-house, gentlemen. We find the kidneys are distinctly diseased, they are mottled, some are contracted, some have white degeneration. I shall take occasion to show you some of these specimens in a few minutes. But here let me say that my conviction is complete as to the existence of some decided connection between the three facts — dropsy, coagulable urine, and diseased structures of the kidneys.

"Some of you may suppose that there are coagulable substances in normal urine. In order to determine the validity of such a supposition, let us take a sample of urine from this patient, who, as you see, has no dropsy and is, indeed, a patient of Sir Astley Cooper's. She has a lipoma, gentlemen — a lipoma. Now, you see, as I boil this patient's urine in the spoon, you notice it remains clear. In fact, gentlemen, we have

thoroughly tested out a number of urines and feel certain that the coagulable property occurs only in the dropsical cases.

"I forgot to say that this little patient you just saw is recovering from scarlatina. Now, gentlemen, here comes your surgical lecturer, and we will close. Ah! Sir Astley—"

A tall, elderly, distinguished-looking man, with the finest eyes the Edinburghian had ever seen in a person's head, walked leisurely in.

"Ah, Richard," he said in his slow, pleasant way, "demonstrating cases of Bright's disease, eh?"

"That's Sir Astley Paston Cooper," whispered the Londoner to his cousin. "He's the greatest surgeon in Europe. He took a wen off His Majesty's head and was made a Baronet for it. By Gad, you should see him do an amputation—it's the twinkling of an eye."

"Come, gentlemen, let us go to the anatomical theatre and I will show you some dissections which . . ." began the great man. And with a rattle, the class started after him.

4. *The Scientific Treatment of Disease*

You say: "I have a little touch of rheumatism."

Your friend says: "You ought to take some aspirin for that."

You say: "How much?"

Your friend says: "Five grains every two hours."

You say: "How shall I take it?"

Your friend says: "Just swallow it with a glass of warm water."

You go and do it blindly because your friend has that manner of assurance.

Did it ever occur to you to wonder how your friend found it all out?

Or your friend says: "For this trouble you ought to sit in a tub of hot water."

And you say: "How hot and how long?"

Your friend says: "110 degrees Fahrenheit for half an hour."

Or the doctor says: "I am going to give you a hypodermic injection of one-quarter grain of morphine for that pain."

Or: "For the spot on your uncle's chin, which is probably a very early cancer, I shall apply radium for such and such a length of time."

Now, how did they learn all these things?

First, how did they find out that aspirin was good for rheumatism,

and morphine was good for pain, and radium for cancer? It wasn't written on them, you know. When the first person who ever saw it saw his first hunk of aspirin, it did not have "Eat me for rheumatism" engraved upon its surface. Looking at a white powder, how did the totally unrelated subject of rheumatism happen to pop into anybody's head? Ditto questions with the others.

And after that the momentous question: how much? One might easily give a poisonous dose the first time, and that would tend to undermine confidence in the product. And too small a dose wouldn't do any good.

Nearly all these things were learned by accident.

Digitalis, or foxglove, was used for the dropsy by an old herb-woman in Shropshire, and William Withering, hearing reports of her cures, began to introduce it, as he says, "into the more regular modes of practice." Epsom salts were found by a cowherd, in solution in the water bubbling out of the ground from the old well on Epsom Downs; cattle refused to drink the water, and the cowherd, in order to learn why, found it had a bitter taste and supposed it had medicinal properties. One of the newest cathartics, phenolphthalein, was used for years by chemists as an indicator (it turns red in the presence of acids) and for this reason was added by government order in Hungary to wine for the purpose of indicating whether any adulteration was present. Among the drinkers of this wine an epidemic of dysentery occurred, mysterious until it was shown to be merely the catharsis of phenolphthalein action. Goats who ate of a berry growing wild in Turkey exhibited a mild hilarity; and the goatherd discovered the coffee-bean.

Following the accidental discoveries came hard work and experiment, using animals first, in most instances, instead of man — "trying it out on the dog," as the saying goes.

Not that men were not willing. "There is nothing men will not do," said Oliver Wendell Holmes, "there is nothing they have not done, to recover their health, and save their lives. They have submitted to be half drowned in water, and half choked with gases, to be buried up to their chins in earth, to be seared with hot irons like galley slaves, to be crimped with knives like codfish, to have needles thrust into their flesh, and bonfires kindled on their skin, to swallow all sorts of abominations, and to pay for all this: as if to be singed and scalded were a costly privilege, as if blisters were a blessing and

leeches a luxury. What more can be asked to prove their honesty and sincerity?"

Space forbids telling the story of all remedies. Let us glance at a few typical ones.

(*a*) *Drugs*

Opium has been used to allay pain since very early times. There is some dispute whether it is the drug referred to as *Rosh* in the Old Testament. It is not mentioned in Hindu literature until after the Mogul conquest. It was not introduced into the West from China, as is widely believed. On the contrary, its home is in Asia Minor. Latin and Greek references to it are numerous and unmistakable.

Opium was peddled in the streets of Rome. Its widespread use in Oriental tropical countries is due to the prevalence of dysenteries there. First used legitimately in the treatment of actual disease, its use as a habitual drug grew from that.

In the course of such long experience rules for the use of opium must naturally have been formulated. How much to give, in the presence of what symptoms, as well as the symptoms on which it had no effect, its dangers, and the treatment of over-dosage must all have been settled.

Had you lived in the Rhine countries about 1525 you might have seen that popular natural philosopher Paracelsus riding through the villages on horseback, setting up his office and interviewing patients at the inn. He always carried opium in the pommel of his saddle and called it "the stone of immortality."

Paracelsus derided the doctors of his day and greatly changed and improved the preparation and administration of many drugs. He introduced metals as drugs. The zinc oxide ointment you use on your skin trouble is one of his inventions. Galen's pharmacy was almost entirely herbs, and among apothecaries they are still known as "Galenicals." Besides his metal therapy, Paracelsus improved many Galenicals.

He introduced a new form of opium. The usual state in which it had been used was the powder or the gum. The gum is a black, sticky mass which looks much like a plug of chewing-tobacco. Paracelsus dissolved some of this in alcohol to form laudanum.

Standardization of drugs came in with the growth of the trade of the apothecary. The apothecary has always been a sort of medical practitioner. In the Middle Ages his shop was the astrologer's shop and the

alchemist's shop. A stuffed crocodile skin hung from the ceiling. A cauldron burned in the oven. Drugs, love-potions, predictions, perhaps even poisons, could be obtained from the solemn, long-robed proprietor. Most of his remedies were secret.

In 1542 or thereabouts a young man who was travelling through the old city of Nuremberg showed one of its physicians a collection of recipes and formulæ for many drugs. The young man, whose name was Valerius Cordus, had assembled these from many sources during his wanderings. The collection was considered so complete that Cordus

Sertürner, who first isolated the greatest of all drugs — morphine. (By courtesy of Dr. P. J. Hanzlik)

was urged to allow the Senate of Nuremberg to print it for the benefit of apothecaries. He consented and left the manuscript in the hands of a committee of physicians. Then he journeyed on to Rome, where he died in 1544. In 1546 his collection was published in Nuremberg under the title of a dispensatory. It is the first of the pharmacopœias, or official lists of drugs with instructions for their collection and preparation. It was followed by many others. *The United States Pharmacopœia,* issued every ten years, revised by a board of pharmacists and physicians, has in its instructions as to the preparation and quality of standard drugs the authority of a law of the land. No drug not included in it is official.

Under the regulation of the pharmacopœias the quality of opium improved, as well as the elegance and potency of its preparations.

The year 1803 was the date of the most momentous single advance made in the scientific application of the drug opium to disease. The scene was a little old-fashioned pharmacy in the city of Paderborn in Prussia. The work was done by a humble drug-clerk named Friedrich Wilhelm Adam Sertürner, who was twenty years old. He had been apprenticed to the Royal Pharmacist Cramer and in Cramer's shop made his discoveries.

The young druggist began to wonder what part of this gummy mass called "opium" really did the work. Here was a black balsam-like mass. Was there any ultimate part of that which drove away pain? Was there another and different part that made you sleepy? Did those things have definite chemical structure?

At odd hours between wrapping up a pennyworth of salts or a fragrant cake of soap, or filling one of those staggering prescriptions that were in vogue among physicians in his day, he began experimenting in the back of the pharmacy. He began by soaking opium gum in distilled water — extracting it, as it is called. This dissolved out certain parts. Then he soaked the gum that was left in alcohol. When he got through, he had a water-soluble part, an alcohol-soluble part, and a solid residue. He had to try these out — on a mouse. It was slow tedious work.

Put yourself in his place. He had to obtain some sort of extract from this substance. Then he had to find out its chemical properties — was it acid or alkali? Then he had to show that it had definite narcotic effects. Then he had to discover the proper dose for a man. Slow work indeed. It took him from 1803 to 1817.

In 1806 he published a paper in which he stated that the great activity of opium was not due to the resin. He could extract a crystalline substance from the resin with ammonia and give the resin which was left to dogs without producing narcosis in them. He recommended that pharmacists extract the opium with strong alcohol, as it produced a more even mixture of active opium and hence the dose could be calculated better. He was not yet ready to announce his ultimate active principle — the method had not been perfected.

For eleven years he struggled to obtain his ultimate pain-killing substance. Everything he did made him surer it was there.

He was over thirty by this time. And while all the work was going on, he had to earn a living. He set up shop for himself in a quaint old pharmacy at Einbeck. There were cakes and ale in the village, I

Cramer's pharmacy at Paderborn, in which Sertürner isolated morphine, in 1803. (By courtesy of Dr. P. J. Hanzlik)

suppose, and pretty girls passed his shop. But the queer young man bent over his table.

He had three young friends. "Will you come to my pharmacy this evening?" he asked them. "We will try an experiment in natural philosophy."

So they arrived. What was the experiment?

"Well, it is only fair to let you know. These crystals here are extracted from opium. I think they are its real active principle. They put dogs to sleep. But — I don't know what is the right amount to give a man. Will you help me out by swallowing some?"

The young men looked at each other — dubiously. Is Herr Sertürner going to take some, too?

Oh, yes, certainly, he will take what they take.

Well — but — yes — they will be brave. They will sacrifice for science. But *please* let it be a little dose at first.

Yes, certainly, only half a grain washed down with alcohol and water.

So they sit there in the little back room of the pharmacy solemnly eating morphine — these four noble adventurers for humanity. The lamp throws their figures grotesquely over the wall. They watch each other apprehensively. Sertürner described his own sensations. After the first half-grain dose he felt elated, there was a flush on his face. Half an hour later he took another dose of a half-grain; he began to get a little nauseated, one of the regular symptoms of morphine; now he felt more lethargic and numb. Half an hour later he took another half-grain, and a dreamy narcotic state came over him; the depression became marked. Here, he concluded, was the point of poisoning. He was right. He had taken a grain and a half. The average dose now, of course, is one-quarter grain.

He stated that since no other part of opium gave these peculiar sensations, morphine was its active ingredient.

Here was a very important generalization. It is possible to separate out the part of a plant which contains its essential medicinal properties.

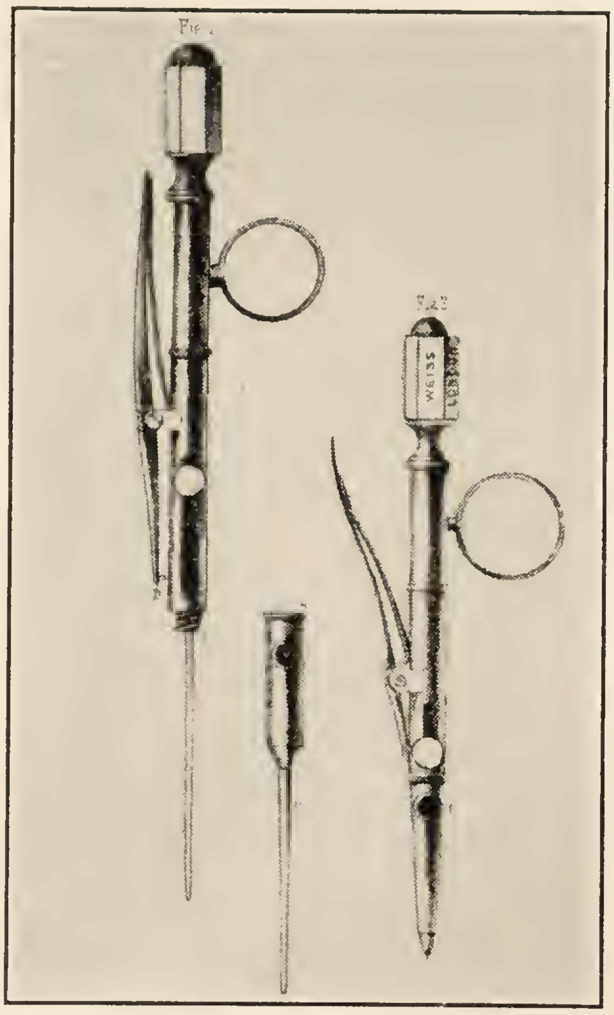
Setürner extracted morphine by soaking an amount of opium successively in bowls of water — one soaking after another. When he had about twenty bowls, he added all the water together. When ammonia was added to this, some crystals were formed. These crystals were morphine, but not in a pure state. He purified them by redissolving them in diluted sulphuric acid, then precipitating them again with ammonia, then dissolving them several times in alcohol, and allowing them to recrystallize.

He described its chemical properties — it was colourless, easily soluble in alcohol and ether, slowly soluble in boiling water. Its taste was bitter.

It turned red litmus blue. Because of its alkaline nature he called it an alkaloid. All these descriptions were put down to aid those who came after. They might go through the same process and get some material and want to know whether it was the same thing as Sertürner had found. If it checked up with his description, it was probably the same.

He named it "morphine" after Morpheus, the God of Sleep.

This work of Sertürner made a great advance in the study of drugs. Here was belladonna, so called because if a lady ate its leaves, it would



Francis Rynd's hypodermic syringe.

make her very beautiful — her eyes would shine, the pupils would become large, her cheeks would flush. But while a lady might eat the leaf of one plant and get this result, she might eat several leaves of another belladonna plant with no effect whatever. And then she might find one plant, from which if she ate one leaf, she would get a tremendous reaction — all the symptoms in the greatest intensity, even going over into a state of poisoning.

The chemical which caused my lady's eyes to shine, her cheek to flush, then, is very unevenly distributed in the leaf of belladonna. But when Mein isolated the active principle of belladonna from the leaves, as

Sertürner had isolated morphine from opium, and called it " atropine," the chemical substance was found. It could be obtained in great quantities. It was exactly the same all the way through — not like the leaves — one pinch was just as potent as another equal in weight.

So, before long, emetine was obtained from ipecac (1817), and strychnine from nux vomica (1817), and quinine from cinchona bark (1820), and caffeine from coffee (1820), and nicotine from tobacco (1881), etc., etc.

Then another question arose. It was all very well to say here they had a substance which abolishes pain, but sometimes they could not get it into the body. Sometimes the patient was vomiting, as in cancer of the stomach, and could not hold the morphine on the stomach. How to get it into the blood-stream? Francis Rynd solved the matter. He invented the hypodermic syringe.

" Description of an instrument for the subcutaneous introduction of Fluids in Affections of the Nerves," so reads the little paper. Published in the *Dublin Quarterly Journal* for 1861.

" The subcutaneous introduction of fluids, for the relief of neuralgia was first practiced in this country by me, in the Meath Hospital, in the month of May 1844. The fluid I have found most beneficial is a solution of morphia in creosote. . . ."

It was not much of a hypodermic Francis Rynd invented, as you can see by its pictures, but it opened the way for others, and for the use of drugs by other channels than the mouth.

(*b*) *Water*

Shop talk among medical men has always been their greatest relaxation. " Queer thing happened the other day," is the way it starts.

A ship's surgeon landed in Jamaica in the mid eighteenth century and told Dr. William Wright, an army surgeon there, of a " queer thing that happened " on his last voyage.

He had a serious epidemic of typhus fever among his crew — a common event in those days of filth and poor hygiene. So many men were stricken that there was not room for all of them in the bunks, so the surplus had to lie out on deck. The medicine ran out.

The poor sick fellows lying on deck in the heat of the sun would beg their companions to dip up a bucket of water from the ocean and

dash it over them. The medical officer did not interfere with this practice. He expected them to die anyhow, and if the water made them more comfortable, why bother?

But the "queer thing" was that they didn't die. They got well in far greater numbers and far more promptly than the supposedly better-cared-for patients in the beds below. And without the drugs of which the bed patients had the benefit.

Could it be that the affusions of cold salt water had any curative effect?

Dr. Wright soon had an opportunity to find out, and that in his own person. On the 1st of August 1777 he embarked on a ship bound to Liverpool. One of the sailors fell sick of fever, and Dr. Wright through his attendance on him and his ministrations caught it. For several days he dosed himself with "gentle vomits," tamarinds, opiates, antimonial wine, and Peruvian bark. But he got no better. He hobbled up on deck; he noticed that the cool air — the colder, the better — mitigated his distress. Then he bethought himself of the queer thing his colleague had recited and he slipped off all his clothes and ordered that three buckets of cold water be thrown on him.

"The shock was great, but I felt immediate relief. The headache and other pains instantly abated and a fine glow and diaphoresis succeeded. Towards evening, the febrile symptoms threatened a return and I had again recourse to the same method as before with the same good result."

He published his experience in the *London Medical Journal,* where it fell under the eye of James Currie, an M.D. of Edinburgh, who was then physician to the Liverpool Infirmary. When fever broke out among the inmates, Currie, to the horror of his colleagues, instituted the cold water cure. But admiration was excited when all seven of the patients so treated recovered.

Currie's *Medical Reports on the Effects of Water, Cold and Warm, as a Remedy in Fever and Other Diseases,* published in 1797, made water treatment popular. The book went through many editions and had a wide influence.

Currie was undoubtedly influenced by his teacher, Cullen, who advocated many forms of water treatment, including alternate or simultaneous use of hot and cold water, still called the "Scotch douche."

Not long after the publication of Currie's book, in the little Austrian

town of Gräfenberg, a farmer boy named Vincenz Priessnitz was kicked by a horse; the heavy cart passing over his chest fractured his ribs. A surgeon called in pronounced the verdict that the lad was hopelessly crippled for life. Vincenz did not, however, accept this depressing verdict.

He had been deeply moved by an experience of his boyhood. Gräfenberg lies in a mountainous country, and while Vincenz was rest-

Vincenz Priessnitz, one of the founders of modern hydrotherapy.

ing beneath a tree near a spring, he had seen a young roe which had been shot through the thigh drag itself into the spring. He saw that it managed to get its wounded thigh into a position so as to have it entirely covered with the flowing water. With breathless interest he watched the poor creature apparently obtaining relief from this instinctive treatment. He saw it return at intervals to renew the bath. Day by day he was rejoiced to see it improve and finally return to health.

His will to get well was strong. He had an oaken arm-chair brought, and placing his abdomen on the edge of it, holding his breath, he pressed the abdomen upwards until he thought the ribs were back in their natural position. He had bandages wrung out of cold water fixed across his chest. The acute pains subsided and he fell asleep. The cold water treatment was continued, every day, until finally he was recovered.

The surgeon and his unhappy verdict were confounded.

Priessnitz became a crusader for water treatment. If he heard of anyone with bruises or sprains or dislocations, he related his experience to them and applied his remedies. His cures were many. His reputation spread until all the country-side was flocking to him with all sorts of ailments.

By the time he was nineteen, his patients came from all Bohemia and Moravia. He used a sponge for baths and affusions. At first he did his work gratis; patients later began to make him presents and substantial cash donations.

His youth, his intense faith in his methods, the scorn with which his experiences naturally taught him to regard the medical profession, brought him envy and vituperation.

Patients came from far and asked for the home of the " water doctor." " The water doctor! " would be the reply; " why take the trouble to see that man? He is nothing but a quack."

His customers were taken before the magistrates to obtain evidence which might be used in bringing accusations against him. One such was a miller, Franz Nietsche. The magistrate ordered Franz to say who had helped him, and Franz replied: " They all helped me — the doctors, the apothecaries, and Priessnitz. The two former helped me to get rid of my money, and Priessnitz to get rid of my illness."

Opposition did not make headway in such an atmosphere.

The priests accused him of being a false prophet and warned their people against " the new superstition." The curate of Vogelseifen threatened to have him imprisoned if he ever showed himself in church. Shortly afterwards the curate fell ill and he was unable to take the journey to some baths the doctors had ordered for him. He humbled his pride and sent for the false prophet, who promptly cured him.

The curate thought that Priessnitz was worth developing and gave him some medical books to read, but Priessnitz returned them in a few

days, saying that they had not caused him to alter his mind, and that he was determined not to read any more of them. His lifelong ignorance of pathology was probably a positive advantage to him. He never recognized an incurable ailment. He never knew when he was licked.

So great was the number of his patients that he had to build houses to accommodate them and bath-houses, and so was established the first modern hydrotherapeutic institute.

In 1829 Priessnitz was arrested and sentenced to imprisonment for treating patients without a proper licence from the faculty or the Gov-

Gräfenberg, one of the first modern spas.

ernment. He appealed the case to the higher court, with the result that in 1831, he was given official permission to conduct a hydropathic establishment.

From that time his life was undisturbed and busy. The size of his practice grew and grew. He gained a reputation for shrewd mother wit. An old woman who lived with her sister, both with vile tempers, asked him how she should treat her tongue when it rebelled at her sister's doings. "When you see a disagreement coming on, take some cold water in your mouth," he replied. To an emaciated patient sent him by some Bohemian doctors he said: "They are clever fellows, those Bohemians — they take the flesh and send me the bones."

He died without apostasy to his opinions. His wife wished to send for a physician. "No," said the sick man. "Is there not God and cold water?" With the unfortunate tendency medical crusaders have to untimely ends, he was only fifty-two at death.

In spite of the resentment and opposition which his work provoked in the regular medical profession, Priessnitz really founded hydrotherapy as a branch of healing. He was too conspicuous to be ignored. For thirty years he had the largest practice in the world. Then, anyone who took the pains to examine his methods was compelled to acknowledge their simplicity and harmlessness. The latter is a very important element of any therapeutic agent.

Baths for curative purposes were a familiar feature of European life, at least from Roman times onward. Priessnitz's accomplishment was to introduce a great variety of procedures and to use them for a great number of diseases.

A Bohemian, Wilhelm Winternitz, who took his degree in medicine in 1857, six years after Priessnitz's death, at the University of Prague, analysed hydropathic procedures and explained the action of water on a scientific basis. Soon after graduation he repeated the experience of William Wright. As a ship's physician he had to treat an epidemic of fever among sailors, and the supply of drugs was soon exhausted. He treated the patients with water, and to his astonishment they recovered more rapidly than with the use of quinine.

After leaving the Navy he visited Priessnitz's Kurhaus at Gräfenberg (the work then being carried on by Priessnitz's successors) and, learning their methods, carried out extensive experiments with water, mostly on his own person. One of them almost resulted fatally. He applied a cold pack to himself in the cellar of his house. The water froze to his body and he had to be released by chopping off the ice.

For thirty years Winternitz published monographs and text-books on the use of water. He established the physiological principles involved. When, in 1892, he was called to Vienna to the chair of the first clinic ever established in hydrotherapy, he could say with pride: "I had taken on myself, as my life-work, to determine that there is no difference between scientific medicine and scientific hydrotherapy as a specialty, but to establish it for the general good of the whole medical world."

Although firmly established on that basis, the use of water is still more neglected by most practitioners than any other method of equal value.

(*c*) *Air*

In 1836 a young man named George Bodington, who had recently graduated from Bart's (St. Bartholomew's Hospital Medical School, London), settled down to general practice in Sutton Coldfield, Warwickshire, England. Among other things, he became interested in the care of the insane and became proprietor of an asylum.

But other things interested him — one was the treatment of consumption. In those days, the diagnosis of consumption was a verdict of death. The victims were abandoned to their fate. The only treatment was to make them comfortable. They were shut up indoors in a hot room, " so they would not catch cold."

Dr. Bodington had a vigorous intellect — a somewhat skeptical one — and quite a share of that tenacity of purpose which is sometimes called stubbornness. When he was called to see consumptive patients, he refused to believe they were inevitably going to die. He hated the stuffy, hot rooms where they were confined. He decided " the only gas fit for the lungs is the pure atmosphere." He proposed to some of these patients " to live in and breathe freely the open air."

He attended an awl-grinder who was persuaded by his arguments and who crawled out of bed at four o'clock in the morning to breathe the fresh morning air of the common. At first the " most miserable, weak and pitiful wretch in the world," to quote the patient's own words. he soon began to feel his lungs open and his strength increase. As he was still alive in 1840 when Dr. Bodington wrote his paper on fresh air in consumption, he may be regarded as a successful example of what was possible in the disease with the aid of fresh air.

Although he treated many cases successfully, Dr. Bodington was regarded with disapproval by other medical men and even by the majority of the laity. It was hard to make people believe that open air was not harmful to the sick. Shaw makes one of his characters in *The Doctor's Dilemma* say: " George Bodington was ruined and driven out of his practice for only opening the windows." But in a letter from Dr. Bodington's grand-daughter I am told: " It is untrue that grandfather was driven out of his practice. He gave up the work for want

of support by the profession, no doubt, and as you know, turned to the care of lunatics. The reviews in the medical papers sneered not too unkindly at him."

Before his death, in 1882, Dr. Bodington saw his ideas fully accepted. In 1859 Hermann Brehmer established the first open-air sanatorium for patients with tuberculosis. It was located in Görbersdorf in the Woldenburg Mountains.

Dr. Brehmer began to doubt the fashionable doctrine of the incurability of tuberculosis when he saw cured spots of tuberculosis in the lungs of bodies at autopsy.

Ten years after he opened his sanatorium he had his most distinguished patient, a young German medical student named Peter Dettweiler. Dettweiler had one day a gush of blood into his mouth. Refusing to accept this as a sentence of death, he put himself under Dr. Brehmer's care at Görbersdorf. His treatment was successful and his case was arrested. And during his stay in Brehmer's sanatorium he became imbued with the idea of establishing such institutions for people of moderate means.

His whole life was spent on this work. He convinced the medical world of the necessity of bed rest for the consumptive. He established the all-the-year-round fresh-air treatment. He introduced the reclining chair and invented the portable receptacle for sputum.

The whole modern treatment of tuberculosis dates from Dettweiler. Had he not had tuberculosis himself, it might never have received such an impetus.

In America a young American physician, Dr. Edward L. Trudeau, had nearly the same experience. He gave up his ambition to join the Navy in order to nurse his dearly beloved brother, who had tuberculosis. He occupied the same room and often the same bed with him, but his sacrifices were in vain. The brother died and Dr. Trudeau, in 1868, entered the College of Physicians and Surgeons in New York to study medicine.

Soon after his graduation the symptoms he knew so well began to be evident in his own person. He consulted an elder colleague, who made a diagnosis of tuberculosis. No wonder, with the experience of his brother in mind, Dr. Trudeau thought his own end was near.

He decided that if he were going to die, he would spend his last days in "the peace of the great wilderness" — in the Adirondacks.

While waiting there to die, he heard of the success of Dr. Brehmer's sanatorium in Germany and, in 1882, established the first sanatorium in America for the treatment of the disease.

Robert Louis Stevenson was treated there. The demonstrated success

George Bodington. He advised fresh air. Portrait lent by courtesy of his grand-daughter, Mrs. W. B. Irvine.

of the work led to the establishment of many other similar institutions in this country.

It is a hopeful fact to others similarly afflicted that Dr. Trudeau's "inevitable" death did not occur until 1915.

(*d*) *Blood Transfusion*

The notion that a sick person could be relieved by removing some of the blood from his body (which meant letting out some of the disease) must have been a very early one. For hundreds of years blood-letting

was the most frequent form of treatment for any serious disease. George Washington in his last illness was bled three times in forty-eight hours. Blood-letting was accomplished by opening a superficial vein, usually in the arm. It was done at the physician's or apothecary's command by the barber (the barber-surgeon). The sign of the barber's trade, the barber's pole, which has not quite disappeared from our streets, is an evolutionary descendant of the sign of the barber-surgeon, which was an arm bound by a tourniquet and holding a basin which was used both to catch the blood and as a dish for making shaving lather: the niche in the side of the old barbers' basins was designed to fit into the customer's neck. In our modern descendant of that sign, the pole represents the arm, the red stripes the flesh, the white stripes the tourniquet, and the globe the bowl.

Almost as early as the notion of getting rid of diseased blood was the thought of replacing it with healthy blood. Young blood for old. The first recorded modern blood transfusion was performed in 1490 in Rome on Pope Innocent VIII, who lay dying of "that terrible disease, old age." A Jewish physician proposed to rejuvenate him by injecting the blood from three young healthy boys into his veins. There was a one-hundred-per-cent result of the experiment — the three boys died, as did also the Pope, and the physician fled away.

The discovery of the circulation of the blood revived interest in the possibilities of transfusion. Two members of that Invisible College whose meeting we attended at Oxford tried it — Christopher Wren and Richard Lower. Lower performed the first successful blood transfusion in 1665 by uniting the artery of one dog to the vein of another dog by means of a hollow quill. Soon at Montpellier a boy sick with a fever and weakened by many blood-lettings was restored by receiving the blood from a sheep.

Using the blood from an animal was the dominating idea of that time. That the characteristics of the animal would be engrafted on the human recipient naturally followed as an item of gossip. There was an epileptic girl at Breslau who, after taking cat's blood, began to perform feline antics — climbing on the roofs of houses, meowing, scratching, yowling, and sitting gazing into a hole in the floor.

Sheep's blood was usually selected for these early experiments. "With Creed to a tavern," writes Pepys on November 21, 1667, "and good discourse among the rest of a man that is a little frantic that the College

have hired for 20 s. to have some of the blood of a sheep let into his body." And on November 30, "I was pleased to see the person who had his blood taken out. He did thus give the Society a relation thereof in Latin, saying that he finds himself better since, but he is cracked a little in his head."

The diseased conditions selected for the early trials of transfusion were insanity and advanced lung and bowel affections; never for the natural reason — acute loss of blood. The reactions must have been severe. So much so that it was prohibited by law. We know now that serious results will occur unless not only the blood from an animal of the same species is used, but even that proper blood grouping of the two human beings involved be observed. And it is probably a good thing for the ultimate salvage of this valuable procedure, that Church and State combined to prohibit its practice.

Not until the nineteenth century was transfusion again proposed. To the genius of James Blundell, an English obstetrician, who died only in 1877, are we indebted for the rescue of this valuable method. He used it in the treatment of severe hæmorrhage after childbirth. He declared that human blood alone was fit for the operation. He used a syringe, as in the modern procedure, and found that blood lost none of its life-giving properties by such handling. The first four patients on whom it was used were in a desperate dying condition, and he saved none of them. But persisting, he resuscitated several women who had lost so much blood that death seemed certain.

Although infrequently performed, it continued to be a subject for study. The severe reactions were the real deterrent. In 1869 Creite showed that the red blood-cells of man would be clumped together if placed in the blood serum of a cat or a dog or a sheep. Landois in 1875 showed that the serum of one species would dissolve the red blood-cells of another species. These two phenomena — agglutination and hæmolysis — were responsible for the reactions of the recipient of blood transfusion.

That it was possible for human blood serum to clump or dissolve the red blood-cells of another human being was the discovery of Landsteiner in 1900. Landsteiner many years later received the Nobel prize for this work. Some human bloods are accepted by other human bloods without clumping or hæmolysis, but others are not. Finally a system of classification of people on the basis of blood "groups" was

Venesection — bleeding; the favourite treatment of the barber-surgeons, seventeenth and eighteenth centuries.

established (by Jansky and Moss) and methods for determining whether a given donor's blood and a given recipient's blood will be safe for transfusion purposes.

In the meantime, also, knowledge of the phenomena of blood clotting had accumulated, and rules for preventing the clotting of the blood while transferring it from donor to recipient were laid down.

It is done now thousands of times a day over the civilized world. A life-saving procedure in emergencies, it is used for many less desperate conditions. Its history is a fine example of how a method of treatment is brought to perfection by slow growth over centuries of time, by the contributions of many men, stumbling through alternate failure and surmounting of difficulties.

CHAPTER XVIII

ANÆSTHESIA

He's a clever operator, is Walpole, but he's only one of your chloroform surgeons," says the patriarchal old doctor in Shaw's play *The Doctor's Dilemma.* " In my early days," he continues, " you made your man drunk; and the porters and students held him down; and you had to set your teeth and finish the job fast."

That is an exact description. Of course, few operations were attempted in the pre-anæsthetic days. Only those which could be done in a jiffy — amputations, for instance.

" When I was a boy," said Sir Clifford Allbutt, " surgeons operating on the quick were pitted one against the other, like runners on time. He was the best surgeon, both for patient and onlooker, who broke the three-minute record in an amputation or a lithotomy."

Charles Darwin was saved from being a doctor by the horror of these spectacles:

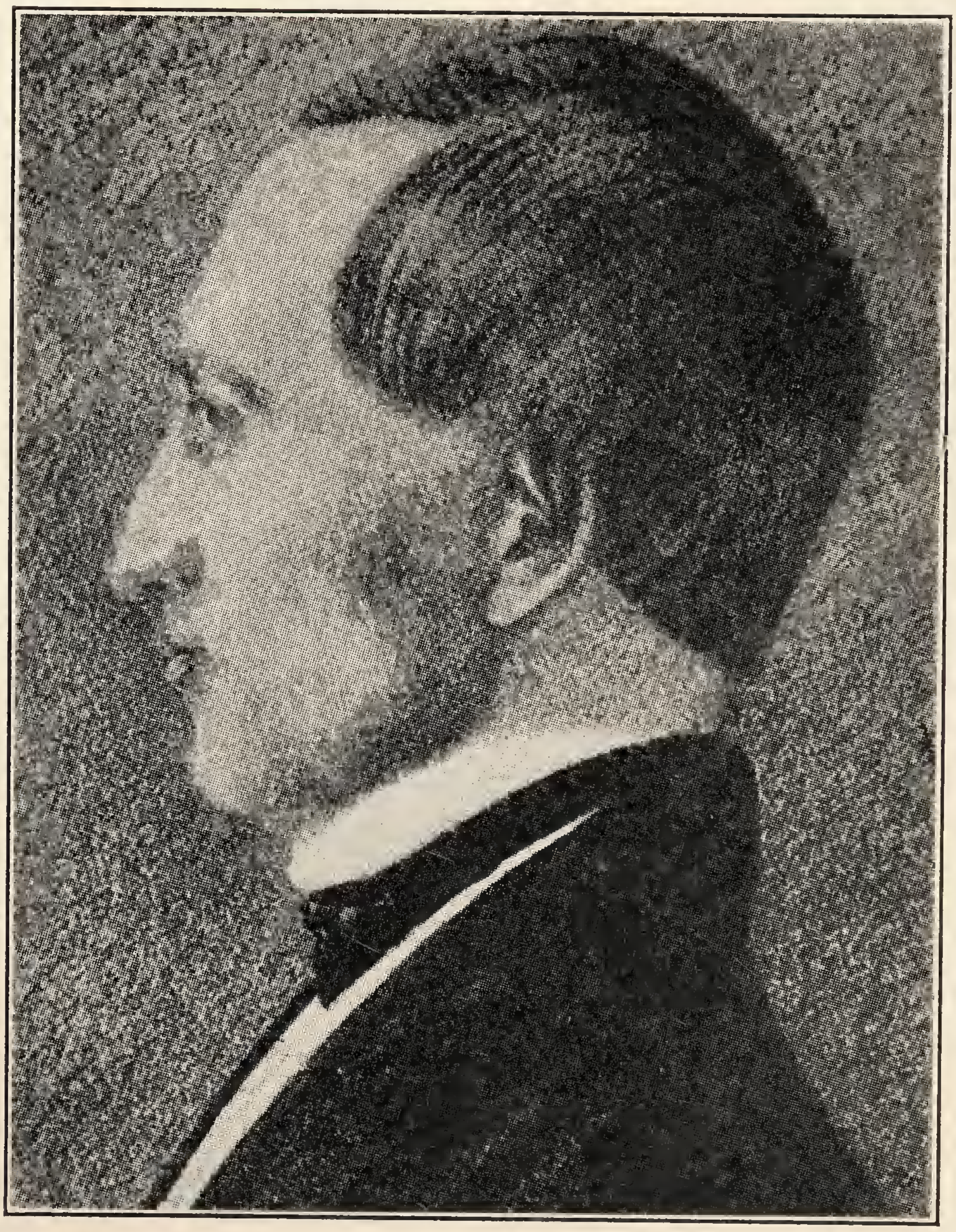
" I also attended," he says, in his autobiography, " on two occasions, the operating theatre in the hospital at Edinburgh, and saw two very bad operations, one on a child, but I rushed away before they were completed. Nor did I ever attend again for hardly any inducement would have been strong enough to make me do so; this being long before the blessed days of chloroform. The two cases fairly haunted me for many a long year."

In the first half of the nineteenth century surgical thought was intensively occupied with the necessity for some method of anæsthesia.

In France the great surgeon Dupuytren deliberately made so insulting a remark to a lady patient that she fainted, and in this condition he operated on her.

Hypnotism and mesmerism were tried.

All failed. Sir Benjamin Brodie, the greatest surgeon of England, in 1847 said, sadly, that while some means to render operations painless was among the greatest needs of mankind, he feared it was but a vain wish and would never be accomplished. Even then the sailing packet containing the news from America about ether was on the water.



Dr. Crawford Williamson Long. His adherents have established his claim to priority in administering ether for surgical anæsthesia.

That many minds were engaged on the problem is evident from the following:

In the hall of the medical building of the University of Pennsylvania there is a bronze tablet on which are the words: "To Crawford W. Long, First to Use Ether as an Anæsthetic in Surgery, March 30, 1842. From his Alma Mater."

In the cupola room of the old part of the Massachusetts General Hospital can be seen the table where Dr. W. T. G. Morton first gave ether in public for a surgical operation, on October 16, 1846.

In Pilgrim's Hall at Plymouth there is an old-fashioned rocking-chair attached to which is a brass plate that reads: "Seated in this chair Dr. Charles T. Jackson discovered etherization February 1842."

In Princes Street, Edinburgh, there is a monument to James Y. Simpson, who in March 1847 proved the anæsthetic properties of chloroform.

There must be somewhere a monument to Sir Humphry Davy, but I do not know where it is. At any rate, in 1800, after he had discovered nitrous oxide (laughing-gas), he wrote: "As nitrous oxide in its extensive operation seems capable of destroying physical pain, it may probably be used with advantage during surgical operations."

If there is a monument to poor Dr. Horace Wells anywhere, I do not know of it either, but on December 11, 1844 he had nitrous oxide administered to himself in order that a tooth might be pulled painlessly.

These are all claimants for the honour of the discovery of anæsthesia.

To whom should the credit be given? When Oliver Wendell Holmes was asked this question he replied: "To e(i)ther."

Let us broaden that sensible conception and say: "To all."

Chronologically we should begin the story with Humphry Davy. In 1798 he was set up at the Medical Pneumatic Institute in Bristol to carry out such experiments as he wished. He became interested in nitrous oxide gas. He found he could inhale it. He found that by inhaling it he produced in his own body a pleasant feeling of forgetfulness and exhilaration.

"Immediately after a journey of one hundred and twenty miles," he wrote, in 1799, "in which I had no sleep the preceding night, being much exhausted, I respired seven quarts of nitrous oxide gas for near three minutes. It produced the usual pleasurable effects. I continued exhilarated for some minutes afterwards, but in half an hour found myself neither more nor less exhausted than before the experiment. I had a great propensity to sleep.

"To ascertain with certainty whether the more extensive action of nitrous oxide compatible with life was capable of producing debility, I resolved to breathe the gas for such a time, and in such quantities, as

to produce excitement equal in duration and superior in intensity to that occasioned by high intoxication from opium or alcohol.

"To habituate myself to the excitement, and to carry it on gradually, on December 26th I was enclosed in an air-tight breathing-box, of the capacity of about nine and one-half cubic feet, in the presence of Dr. Kinglake. After I had taken a situation, in which I could by means of a curved thermometer inserted under the arm, and a stop-watch, ascertain the alterations in my pulse and animal heat, twenty quarts of nitrous oxide were thrown into the box.

"For three minutes I experienced no alteration in my sensations, though immediately after the introduction of the nitrous oxide the smell and taste of it were very evident. In four minutes I began to feel a slight glow in the cheeks and a generally diffused warmth over the chest, though the temperature of the box was not quite 50 . . . in twenty-five minutes the animal heat was 100, pulse 124. In thirty minutes, twenty quarts more of gas were introduced.

"In three-quarters of an hour, the pulse was 104 and the animal heat not 99.5, the temperature of the chamber 64. The pleasurable feelings continued to increase, the pulse became fuller and slower, till in about an hour it was 88, when the animal heat was 99. Twenty quarts more of gas were admitted. I had now a great disposition to laugh, luminous points seemed frequently to pass before my eyes, my hearing was certainly more acute, and I felt a pleasant lightness and power of exertion in my muscles.

"I existed in a world of newly connected and newly modified ideas. I theorized; I imagined that I made discoveries. When I was awakened from this semi-delirious trance by Dr. Kinglake, who took the bag from my mouth, indignation and pride were the first feelings produced by the sight of persons about me. My emotions were enthusiastic and sublime; and for a minute I walked about the room perfectly regardless of what was said to me. As I recovered my former state of mind, I felt an inclination to communicate the discoveries I had made during the experiment. I endeavoured to recall the ideas — they were feeble and indistinct; one collection of terms, however, presented itself, and, with most intense belief and prophetic manner, I exclaimed to Dr. Kinglake, 'Nothing exists but thoughts! The universe is composed of impressions, ideas, pleasures, and pains.'"

Everyone who has ever taken nitrous oxide has experienced this sen-

sation of seeing into the heart of things, of understanding the great why of the universe. And everyone, like Sir Humphry, has experienced the disappointment of not being able to remember the secret when he woke up. Indeed, Mr. Carl Van Vechten has told me of a fellow-novelist who became so obsessed with the elusive nature of this experience that he had a tank of nitrous oxide installed in his basement and employed a nurse to give it to him. He took it day after day. Each time he firmly decided to remember the real secret of the universe. Each time he went under, the mystic and awful explanation was vouchsafed him. But invariably when he regained consciousness, he could no longer remember what it was.

Sir Humphry's experiments proved, first, that it was safe to inhale nitrous oxide. And in 1800 he stated that he believed it could be employed to deaden pain in surgical operations. But the suggestion fell on deaf ears, and no trial was made of it for forty years.

In 1842 there graduated from the Baltimore College of Dental Surgery a gentleman named William Thomas Green Morton. As soon as he had received his diploma, he went to Boston and set up in the practice of dentistry in partnership with Dr. Horace Wells, a man four years his senior.

Both of these dentists were clever. They were ingenious mechanics and ahead of their time in devising methods of making bridges and false teeth. One difficulty got in their way. Most dentists at that time made a plate of false teeth which they attached to such old teeth or fangs, or remains, which had resisted the inevitable processes of time and still remained in the victim's mouth. This sort of procedure Wells and Morton considered " stupid and barbarous."

They wanted to pull out all the teeth in the patient's mouth before inserting the plate. The patients were perfectly willing on æsthetic and mechanical grounds, but most of them objected because of the *pain* involved. So the progress of Wells's and Morton's improvements in dentistry foundered on the rock of pain. There must be some agent, both of them thought, that could be employed to deaden the sensations of a patient for the few minutes required to pull a tooth. The minds of both these men were consequently intensely engaged on this problem.

A year after the formation of their partnership they dissolved it, by mutual agreement.

Wells went to Hartford, Connecticut, to practise, and while there he

attended one day a lecture on chemistry. The subject of the lecture was nitrous oxide gas. The lecturer invited any member of the audience who was so disposed to come down into the amphitheatre and inhale the gas in order to test its effects. Several accepted. Young Dr. Wells watched them under the influence of this gas.

The habit of getting drunk, it is my painful duty to record, haunts the record of this discovery of the "greatest boon ever conferred on mankind." If it were not for that reprehensible human desire for gaiety and oblivion, I fear anæsthesia would never have been attained. All the young men Horace Wells watched at his chemical lecture got drunk when they inhaled nitrous oxide.

Horace Wells. His patient died of laughing-gas.

One fellow flew about wildly bumping into chairs, falling down, bruising himself badly, but not apparently minding it. After he came out, Wells questioned him.

Had he felt no pain when he hit his shin against that chair?

"None in the least."

Nor when he got that bump on the forehead?

"Didn't even know he had a bump."

Well, here was food for thought.

About a year later, on December 11, 1844, Dr. Horace Wells went to Dr. G. Q. Colton, a well-known lecturer on scientific subjects in Boston, and persuaded him to administer nitrous oxide to Wells himself while Dr. John M. Riggs pulled a tooth. The patient went to sleep, the tooth was pulled; he spit, he gasped, he awoke; he spoke; he said: "A new era in tooth-pulling."

In all the acrimonies of the future no one ever tried to take the credit for this away from Horace Wells. But he was unfortunate in his discovery, as was everyone associated with the development of anæsthesia. He tried to give a public demonstration of his agent and failed. He used it on a patient who died. In 1848 he cut his own radial artery at the wrist and bled himself to death.

His old partner Morton pursued the same idea, but arrived at a different place. He tried giving his patients brandy and champagne, and laudanum and opium. Here is one of his case reports:

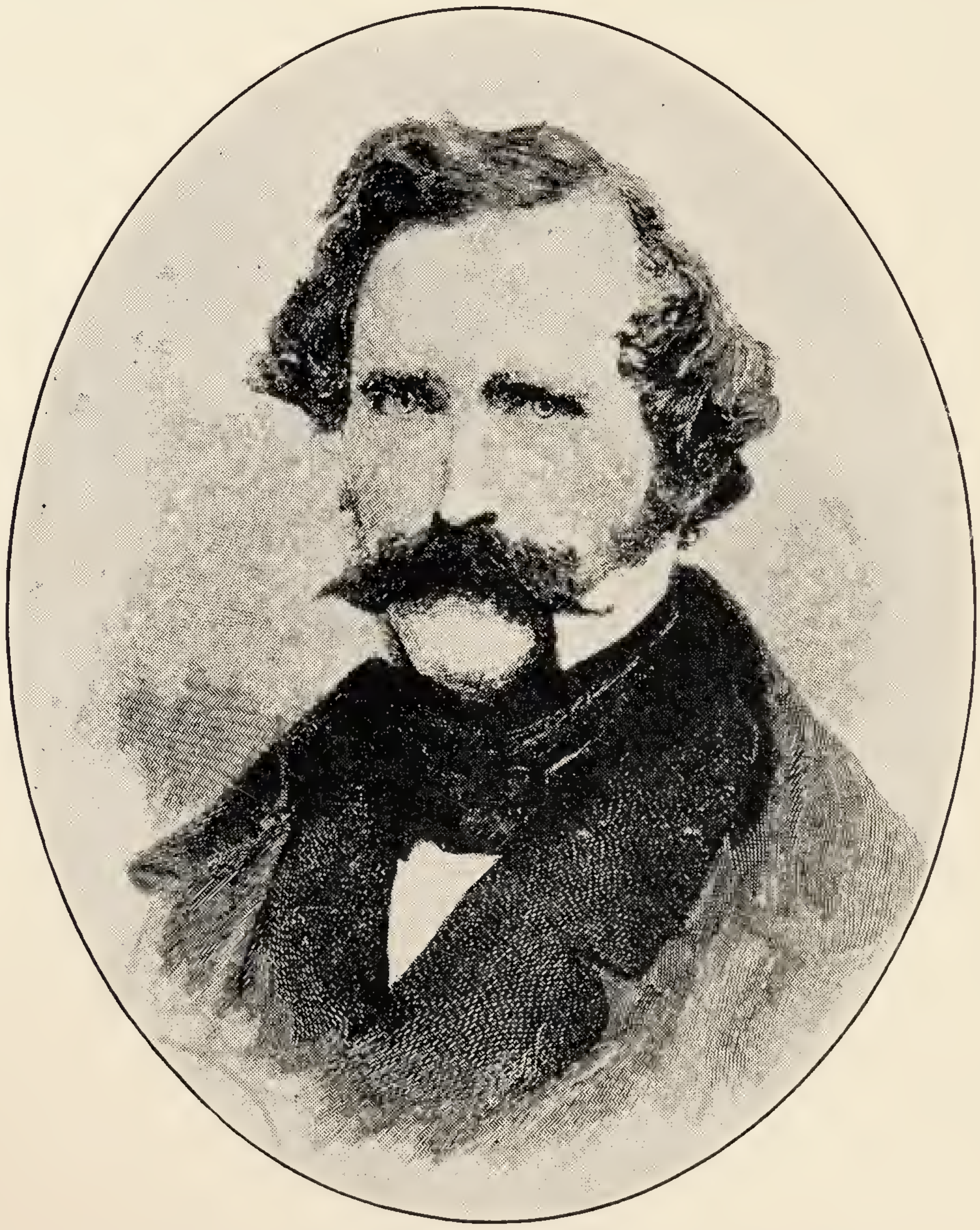
"Mrs. S. — to have . . . teeth of both jaws extracted. Commenced giving opiates about noon. Gave . . . 150 drops of laudanum. Twenty minutes later gave 150 more. Waited ten minutes and gave 100 drops more. Gave 100 drops more with intervals of five minutes. Whole amount given, 500 drops in forty-five minutes. At expiration of this time she was sleepy but able to walk to a chair. Immediately on extraction of the first tooth she vomited. She continued this way for one hour, during which time the rest of the teeth were extracted. She was conscious but insensible to a considerable degree. On returning home she continued to vomit at intervals during the afternoon. Entirely recovered in a week."

You can see that the dangers and the disagreeable after-effects of laudanum were too great. Morton finally decided he needed to know more about medicine, so he entered the office of Dr. Charles T. Jackson of Boston.

Jackson was a queer hodge-podge. He was an explorer, mineralogist, physician, chemist, and the sort of general naturalist common enough at that period. The members of the Pickwick Club were of his stamp.

Perhaps that is why Morton chose him rather than a strictly orthodox physician — he had ideas.

Morton made quite a sacrifice to go into medicine. For May 1844 his accounts foot up to $1,126.50. Do not ask me what the fifty cents represents. It would never appear on the credit side of a modern dentist's ledger, but that eleven hundred odd dollars was a good amount for a



W. T. G. Morton. His patient was ready for the ether.

month of dental work in 1844. Yes, Morton made a sacrifice, but he was a man possessed. The dream of relief from pain would allow him no rest.

We may be sure that Morton talked over his problem with his new preceptor, Jackson. Jackson told him a very queer thing. This was it:

In 1842 Jackson was lecturing on chemistry at a public hall in Boston. Suddenly an accident occurred, a large glass jar filled with pure chlorine broke and the lecturer got his lungs filled with the irritating gas. It is like some of the gases used in modern warfare. There was a

bottle of sulphuric ether and ammonia handy, and Jackson had these brought to him and inhaled them alternately with great relief. He went to sleep without suffering. But he realized it had only been deadened, because the next morning he awoke in great pain from the inflammation in his throat. " I determined, therefore," he said, " to make a more thorough trial of ether vapour, and for that purpose went into my laboratory, which adjoins my house in Somerset Street, and made the experiment from which the discovery of anæsthesia was deduced."

He sat in the chair which is now exhibited in Pilgrim's Hall at Plymouth, and putting a handkerchief saturated with ether over his face, he inhaled it until all sensation of pain, and even consciousness, was lost.

" Reflecting on these phenomena, the idea flashed into my mind that I had made the discovery I had so long a time been in quest of — a means of rendering the nerves of sensation temporarily insensible, so as to admit of the performance of a surgical operation on an individual without his suffering pain therefrom."

This was the story his preceptor told Morton. Let it be noted that while Jackson thus discovered the properties of ether, he never put it to the test — he never used it in a surgical or dental operation. And in medicine, as nowhere else, the rule is: " By their fruits ye shall know them."

In September 1846 a person with the good New England name of Eben Frost rang Dr. Morton's doorbell and was admitted. His face was swollen and bandaged. He was in that state " of mingled hope and consternation so familiar to all dental surgeons." He wanted his tooth out, but he did not want to be hurt. He asked Morton if he could not mesmerize him so as to avoid the pain. Morton replied he had something better than mesmerism. He explained about ether. He was sure it would relieve pain, but also perhaps it would kill the patient. Eben Frost eagerly consented to its use. The fear of death did not possess him. Beside the agony of having that exquisitely sensitive tooth out, death would be a relief. He seated himself in the chair. He inhaled the ether. When he was snoring nicely, Morton pried open his jaws, and grasping the offending tooth (" a firmly rooted bicuspid "), he pulled and crunched and yanked it out. Not a movement from his patient. Not a word of protest. Morton stood in his room with his forceps in his hand, and in the jaws of the forceps was the abscessed tooth, and snoring in

the chair was the patient. But had he killed him? Would Eben Frost live? At that second a groan escaped him, and horrors! — a blasphemy. He rose and spat. He blinked. He gesticulated. He lived. He lived to sign affidavit after affidavit in petitions to Congress for the patenting of Morton's discovery.

So the thing was proved for dentistry, at any rate. Would it work for surgery? Morton applied to Dr. John Collins Warren, Professor of Surgery at Harvard Medical School. Dr. Warren was then nearly seventy years old and almost incredibly venerable. He was known in every surgical clinic in the world. He was a man of irreproachable character and honesty. He had probably never told a deliberate lie in his life. His word, his endorsement, was worth the amalgamated certificate of all the rest of the surgeons in Christendom. If he got behind this thing, Morton calculated, it would be a success. And his calculations were subsequently abundantly justified.

On October 14, 1846 Morton received a letter from Dr. Warren requesting him to hold himself in readiness to administer " the preparation " which he had " invented to diminish the sensibility to pain " to a patient who was to undergo operation two days later.

On October 16, 1846, then, in the surgical amphitheatre of the Massachusetts General Hospital, the benches were crowded, and Dr. Warren and Dr. Bigelow, with others, awaited Dr. Morton's arrival.

Dr. Warren explained in his usual dignified manner some of the circumstances under which they were met together.

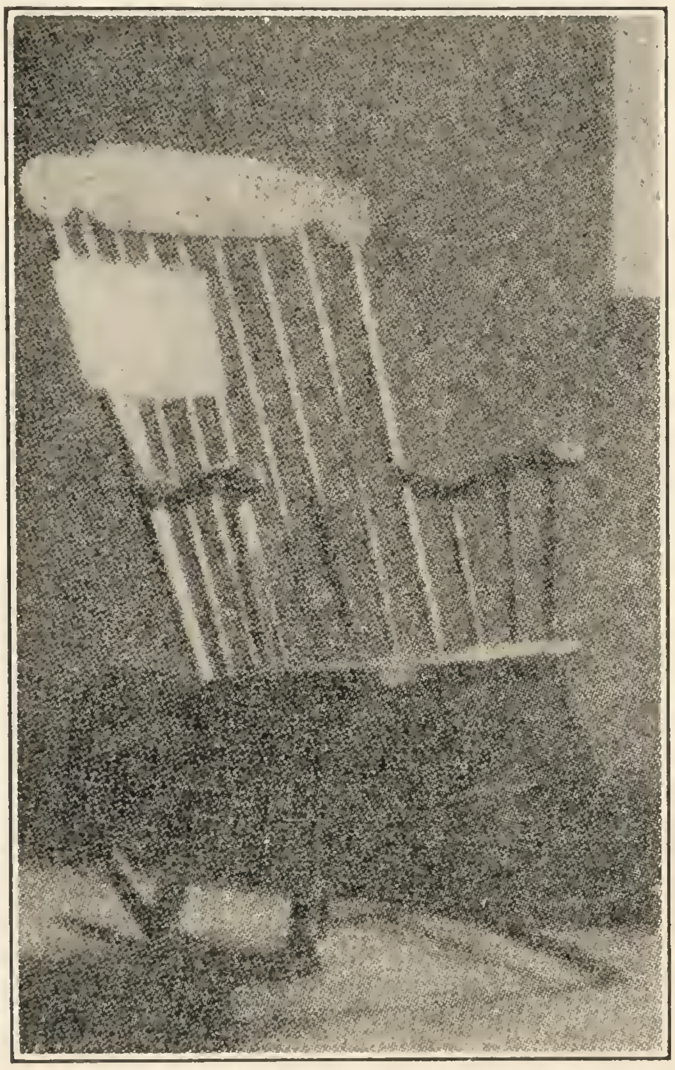
The patient, he showed, had a vascular tumour of the neck just under the jaw. He went into the nature of the tumour quite thoroughly.

Turning from his patient then and facing his audience, he said that, as they knew, he had been forty years a surgeon in Boston. During that time many people had come to him with the information that they were possessed of a method of alleviating the pain of a surgical operation. " On account of the great blessing it would be to the human race if such an agent could be discovered," said the old gentleman, " I have heard what they had to say. If I thought there was no danger to be apprehended from the remedy, and if they were persons whose characters and standing seemed to entitle their opinions to respect, I have made the experiment desired. Thus I have tried galvanism, magnetism and hypnotism." And as he mentioned these methods, his lips curled in a smile of disdain.

"But in every instance when the knife was applied to live tissue there was pain."

The audience rustled with anticipation as Dr. Warren paused in his clinical talk.

"About five weeks ago[1] Dr. Morton, a dentist of this city, informed me that he had invented an apparatus for the inhalation of a vapor, the effect of which was to produce a state of total insensibility to pain and



Chair in which Dr. Charles T. Jackson first administered ether to himself for purposes of anæsthesia. Pilgrim Memorial Hall, Plymouth, Mass.

that he had employed it successfully in a sufficient number of cases in his practice to justify him in a belief in its efficacy. He has wished for an opportunity to test its power in a surgical operation, and I have agreed with him as to the propriety of such an experiment."

[1] These words are extracted from a communication of Dr. Warren's made when the "ether controversy" concerning Morton's claims to patent rights were in dispute, and all of Dr. Warren's dates are not accurate. For instance, he places the first operation on October 17, when all other records agree it was October 16. It could hardly have been five weeks before that Morton applied to Dr. Warren for permission to use ether, as he anæsthetized Eben Frost on September 30, 1846.

The old gentleman here looked all around him, and a cloud appeared on his brow.

" I have asked him to be present this morning to administer the agent to this patient and he agreed to do so."

Again Dr. Warren looked around. He was trying to locate Dr. Morton. But Morton had not arrived. The impression was that he had himself become doubtful and funked at the last moment.

" As Dr. Morton has not arrived," said Dr. Warren, sarcastically, " I presume he is otherwise engaged." And picking up an instrument, he signed the attendants to hold his patient as he intended to go on in the usual way.

But fortunately word came just then that Morton was in the building. He had been delayed in completing the apparatus he intended to use.

As he entered the room, Dr. Warren said: " Well, sir, your patient is ready."

Morton came forward. He held a glass globe, perhaps eight inches in diameter, in his hand. It had a mouthpiece attached and a hole in the top, stopped with a cork. A clear liquid sparkled inside.

Morton leaned down and whispered a few words of instruction to the patient. Then he removed the cork from the top of the globe, and the patient began to inhale.

In the silence of the large room only the patient's gasping respirations could be heard. Three minutes passed by and then Dr. Morton looked up at the older man.

" Dr. Warren, *your* patient is ready."

Dr. Warren made an incision three inches long over the tumour. The patient turned and muttered incoherently, but still seemed unconscious while the growth was removed.

When Dr. Warren had finished, the patient began to speak incoherently.

" Did you feel any pain ? " Dr. Warren asked.

The patient blinked dumbly and spat. " Feel 'sif m' neck's been scratched," he mumbled.

" Is that all ? " Dr. Warren asked.

" That's all," said the patient.

The attendants wheeled him out and Dr. Warren looked about him. Not a soul on the benches moved. They all felt as if they had been witnesses of some momentous event.

" Gentlemen," said Dr. Warren, huskily, " this is no humbug."

The subsequent history of anæsthesia follows two lines. While the medical profession of the world eagerly accepted the new discovery, tested it out, proved its value, gave it freely to all who needed it, the various discoverers engaged in a selfish and disgraceful scramble for monetary gain. From that feud only Crawford W. Long emerged with any honour.

Let us first recount the course of the acceptance of ether as an anæsthetic agent by the surgeons of the world. On November 18, 1846 the *Boston Medical and Surgical Journal* printed an article by Dr. Henry J. Bigelow in which the action of ether for purposes of surgical anæsthesia was formally announced to the medical world. " It was largely due to the high character and repute of such men as Warren and Bigelow that ether anæsthesia was taken up all over the world," says Dr. Garrison in his *History of Medicine.* Robert Liston of London amputated a thigh under ether in December 1846. Syme in Edinburgh, the father-in-law of Joseph Lister, who was later to solve the third great problem of surgery, began to use ether in 1847. Pirogoff, the greatest surgeon in Russia, who was serving with troops in the Caucasus, in 1847 published a favourable report of his experiences with ether in military surgery. Thus the method spread rapidly into all parts of the civilized world.

The effect on the advance of surgery (and of obstetrics when Dr. J. Y. Simpson introduced chloroform anæsthesia for childbirth) can hardly be over-estimated. Not only were more operations performed, but surgeons could take their time. They could work slowly and deliberately. The slapdash methods imperative when the patient was in agony gave place to careful dissections, with correspondingly better results.

Animal experimentation gained a new lease of life. Animal bodies could be used for settling disputed questions at the same time that humanitarian decencies were observed. Physiology, in the discovery of ether, received as much from practice as she had given.

The other side of the picture is far from pleasant. In 1846 Morton tried to patent ether under the name of " letheon." In 1849 he petitioned Congress for a reward for his discovery. Jackson, his preceptor, vigorously opposed these attempts, as did the friends of the dead Horace Wells. The celebrated ether controversy thus began and the halls of Congress rang with its acrimonies for several years.

In 1854 the claims of Dr. Crawford W. Long of Athens, Georgia,

were brought to the attention of Jackson and he paid a visit to Long at his office. Dr. Long seems to have satisfied Dr. Jackson completely that he was entitled to priority for having used ether for practical purposes in surgery. Jackson still claimed priority of discovery of the anæsthetic properties of ether on the basis of having inhaled it himself in February 1842. Jackson proposed that he and Long lay their claims jointly before Congress, Jackson to claim the discovery and Long the first practical use. This was rejected by Long.

The basis of Long's claims are as follows:

On numerous occasions prior to 1841 he had inhaled ether for its exhilarating qualities and frequently, at a short time subsequent, discovered painful bruises on his person, evidently received while under the influence of ether.

" In December 1841 or January 1842 " a company of young men in the little town were discussing the inhalation of laughing-gas and desired the doctor to administer some of it to them in order to observe its effects. He had no laughing-gas, but suggested some sulphuric ether as a safe substitute. They all inhaled some ether, became pleasantly exhilarated, and the custom became so widespread that such parties were known as " ether frolics " and were indulged in throughout several counties in Georgia.

A Mr. James M. Venable had frequently consulted Dr. Long in regard to the propriety of removing two small tumours on the back of his neck. The dread of the pain had dissuaded him, but when Dr. Long recommended that the operation could be done painlessly under the use of ether, Mr. Venable consented.

On March 30, 1842 Mr. Venable was given ether on a towel, and one of the tumours was removed by Dr. Long. " The patient continued to inhale ether during the time of operation and when informed it was over seemed incredulous. He assured me that he did not experience the slightest degree of pain from its performance." [1]

These facts are so well attested that it is generally agreed that the credit for the discovery and application of ether as an anæsthetic agent should go to Crawford W. Long.

It must be admitted, however, that if Morton had not been permitted to use it four years later in Boston, and if Dr. John C. Warren

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[1] Dr. Long's own statement.

and Dr. Henry J. Bigelow had not given it wide publicity in the scientific world, it would probably never have been known. Dr. Long was not a pusher and he made no announcement of his use of ether in any medical journal until 1849, in the *Southern Medical and Surgical Journal.* This publication was evidently the result of the wide interest in the Boston report. During the invasion of Georgia in the last year of the Civil War he placed the papers which confirmed his discovery in a bottle and entrusted them to his daughter, who was fleeing to a distant part of the country before the advance of the Federal troops.

He was, we may assume then, quite conscious of the importance of his work and of his priority. For many years he went unrecognized. He persistently refused to attempt to enrich himself at the expense of suffering humanity.

Of all the claimants, he alone emerges from the ether controversy with an unspotted crest.

CHAPTER XIX

THE PERILS AND PAINS OF CHILD-BIRTH

As the last minutes of the old year were passing, three rubicund old gentlemen sat sipping their port in the library of Dr. Charles White of Manchester.

Glancing at his watch, the doctor rose to his feet and said: "Come, gentlemen," drained his glass, and left the room, followed by the others. He led them upstairs and then up a second flight into a large room where a stuffed hedgehog, a starfish hanging from the ceiling, and the rows of cases indicated plainly that it was a museum of natural history.

Dr. White passed by all the specimens and walked directly to an upright cabinet, which looked like a mummy case. Motioning the others to draw close, he held a candle level with his head and, taking a key from his pocket, opened a kind of door at the head of the case and swung it back on its hinges.

Lifting a veil of cloth, he revealed the face of an elderly woman. Dead! — but in a remarkable state of preservation. The skin appeared under the candlelight as soft, the lips as red, as in life.

"Good God!" exclaimed one of the gentlemen.

"Recognize her?" asked Dr. White.

"Certainly! 'Pon my soul. Looks same as she did last time I dined with her."

"Good job, that, Charles," said the third. "Dashed if I can see any change from last year."

"Sheldon did it," said the doctor calmly. "Had quite a knack. Embalmed his mistress, yu know. Kept her body in his sleepin'-quarters. Don't think I should care for that. Might be embarrassin' to some other

nocturnal visitor. Come along down, if you're satisfied, and sign the documents."

Ominous as this scene might appear to a stranger, it was, in reality, innocent enough. Dr. Charles White, the best surgeon in the north of England, had attended a lady, Miss Hannah Beswick, who had a morbid dread of being buried alive. When she died, in 1757, it was found that she had left a bequest of twenty-five thousand pounds to Dr. White in recognition of the inventive skill with which he had alleviated her sufferings, but with the proviso that her body be embalmed and kept above ground for a hundred years, and that once a year Dr. White, during his lifetime, with two witnesses, should lift the veil from her face. He performed this rite every year for the fifty-seven remaining years of his life. The body of his patient was finally buried in 1868.

But it is not for his attendance on this maiden lady that we bring Charles White into this narrative. His medical fame rests on the experience gained in the treatment of women in childbirth, and the publication in 1773 of his *Treatise on the Management of Pregnant and Lying-in Women,* the first chapter of which was " Of the Courses and Symptoms of the Puerperal or Child-bed Fever."

When men replaced women in the confinement room and began to use the forceps and make frequent examinations during labour, there was noted a great increase in the incidence of what was called " childbed fever." Childbed fever began usually with a chill on the fourth day after the baby's birth. Following the chill, the fever rose, accompanied by distention of the abdomen. Death nearly always occurred, cases of recovery being considered curiosities. At autopsy a general peritonitis and widespread formation of pus throughout the body was found.

The number of cases of this devastating plague which occurred among men-midwives almost ruined the young new science of obstetrics which they were creating. The midwives, however, had their share of cases. But the mortality of the disease in hospitals and in care of physicians came to be a byword. It occurred all over Europe. In 1774 at the Dublin Lying-in Hospital 13 women out of 280 delivered died of childbed fever. In Paris a report on its largest hospital announced: " The Hôtel Dieu . . . loses more than half of the women it accouches." In Vienna in 1846 the First Clinic at the University lost from childbed fever over eleven per cent of the 4,010 patients it delivered. " There is no tone deep enough for regret, and no voice loud enough for warning,"

wrote Oliver Wendell Holmes in his fateful essay on the subject in 1843.

What was the cause? There was no lack of opinion on this question. The professors of obstetrics considered a " miasma." The wandering of the mother's milk and settling in the uncontracted womb also received a share of their profound consideration. A " putrid atmosphere " and " too long confinement in the horizontal position " were put forward.

But here and there a few voices began to utter uncomfortable suggestions. One of the earliest was Charles White's. White is principally remarkable for having suggested that the contents of the womb after childbirth might become putrid and that by setting the patient up early, good drainage would be facilitated. As to the real cause of the putridity he had no clear ideas.

Alexander Gordon of Aberdeen wrote in 1795 *A Treatise on the Epidemic Puerperal Fever.* " By observation," he said, " I plainly perceived the channel by which it was propagated, and I arrived at that certainty in the matter, *that I could venture to foretell what women would be affected with the disease upon hearing by what midwife they were to be delivered.*"

This was uncomfortable doctrine.

But " Gordon of Aberdeen " did not spare his own branch of the profession or even himself. " It is a disagreeable declaration for me to mention, that I, myself, was the means of carrying the infection to a great number of women.

" The analogy of the puerperal fever with erysipelas will explain why it always seizes women after and not before delivery. For at the time when erysipelas was epidemic almost every person admitted into the hospital of this place with a wound was soon after his admission seized with erysipelas in the vicinity of the wound."

But few people heeded these shrewd observations until Oliver Wendell Holmes quoted them in the essay mentioned above.

This effusion of a mere teacher of anatomy, who at the time of its publication did not even hold a university position, met with active opposition and scorn. Meigs and Hodge were the professors of obstetrics respectively at Jefferson Medical School and the University of Pennsylvania. Both attacked Holmes vituperatively. Meigs was the dialectician and sarcastically pointed to the many cases of women during an epidemic of childbed fever who did not contract the disease. Hodge had a

Statue of Ignaz Philip Semmelweiss in Budapest. He discovered the method of preventing death of mothers from infection after childbirth.

more ponderous intellect and trained his heavy artillery on the young Bostonian.

In spite of the bombardment, Dr. Holmes seemed to be very much alive. " As to the utility of negative facts," he replied to Meigs's sarcasm mentioned above, " instances, namely in which exposure has not been followed by disease — although like other truths they may be worth knowing, I do not see that they are like to shed any important light on the subject before us. Children that walk in calico before open fires are not always burned to death; the instances to the contrary may be worth recording; but by no means if they are to be used as arguments against woolen frocks and high fenders."

But the major engagement of the war was still in the offing. Holmes, after all, was not actively engaged in practice. He could not prove by his own experience his own contentions. In 1844 there was graduated from the medical department of the University of Vienna a shy young Hungarian, Ignaz Philip Semmelweiss. He was especially interested in obstetrics, and in 1846 was made assistant to the First Obstetrical Clinic.

Before long he began to notice some peculiar things. He found a woman crying because she had been assigned to his clinic to have her baby. She wanted to go into the Second Clinic, where the midwives presided. Why? Because so many women in the First Clinic died of childbed fever.

Could this be true? Semmelweiss was proud of his profession, of the long years of study which had gained him his degree. Yet here was a woman who preferred — nay, demanded — that she be placed in the hands of the ignorant midwives. Rather than in the hands of the doctors! Was there any basis for so fantastic a belief?

Semmelweiss collected some statistics. He found that in the First Clinic — his clinic — 1,989 women had died in six years. In the same period only 691 had died in the Second Clinic. Nor was that all! Semmelweiss knew only too well that it was the habit to transfer dying women from the First to the Second Clinic to improve the mortality records of the former.

He began to talk about puerperal fever to everyone. But everywhere he found confusion. " All was doubt and difficulty," he wrote; " only the great number of deaths was an undoubted reality." Few of his colleagues were interested. They were devising new instruments and new fanciful treatments. Puerperal fever was puerperal fever. It was there, always had been, always would be. Too bad, but there you are.

These professional shrugs did not discourage Semmelweiss. His whole life became a study of childbed fever. He compared the incidence of cases to the season of the year; there was no relation. He wondered if the disease was brought into the hospital from Vienna, but found it was often raging in the hospital when there was hardly a case in the city outside.

He attended autopsies on the unfortunate victims. He became thoroughly familiar with the post-mortem appearances of puerperal fever. Then one day a curious thing happened. His friend Dr. Kolletscha was performing an autopsy. The knife which was used for dissecting slipped and cut Kolletscha's hand.

Four days later he had a chill. His fever rose. Semmelweiss visited him.

Something peculiar in the features of the case struck him. A *man* with childbed fever!

Semmelweiss walked home, slowly, pondering.

Kolletscha died. Semmelweiss attended the autopsy. The appearances were exactly the same as in the bodies of the victims of puerperal fever.

What did this mean? To Semmelweiss, acquainted with all the routine of the hospital, it came as a revelatory flash of lightning. The students examined the women in the First Clinic; only the midwives examined those in the Second Clinic. The students came into the First Clinic from the dissecting-room, and without even any preliminary washing of the hands examined the patient. The midwives did no dissecting. The poison from a dead body had entered Kolletscha's hand and caused a condition like puerperal fever in him. Couldn't the poison from the dead bodies in the dissecting-room be brought on the hands of the students and so infect the women?

At least, Semmelweiss determined to try the idea out. He would require the students to wash the "cadaveric poison," as he called it, off their hands before examining the patients. He issued orders that every student must wash his hands in chlorine water before entering the clinic. Chlorine water was a disinfectant as well as a cleansing agent. Later a solution of chlorinated lime was used.

The orders were carried out. Soon word got round that the deaths in the First Clinic from childbed fever were on the decrease. Semmelweiss could not wait until the end of the year to compute his mortality. At the end of seven months he announced that it had dropped from twelve to three per cent.

During the next year only a little over one per cent of the women committed to the care of the First Clinic died in childbirth. From March to September 1848 there was not a single death from childbed fever.

This was long before the days of our knowledge of germs. What was the nature of the contagion which was conveyed to these women? Semmelweiss at first called it "cadaveric poison" because he believed it came from the putrefaction of dead bodies. His experience up to a certain time taught him that it was transmitted only from dead bodies to the living. Late in 1847, his first year of trying out his theories, however, he had an experience which changed his views. A woman with an infected cancer of the womb entered his clinic. Her bed was placed in the middle of a row of twelve. The students had been instructed to wash their hands before entering the ward, but not necessarily between every examination. Soon after the patient with the infected cancerous womb entered the ward, childbed fever again flared up and eleven of the patients in the ward died. So Semmelweiss concluded that putrid matter from both dead and living bodies can spread the infection. He changed his orders so that the students were required to wash and then to disinfect their hands in chlorine water between every examination. With the establishment of this regulation puerperal fever almost disappeared in his clinic.

The proof of Semmelweiss's contentions seems so clear and incontrovertible that it appears ridiculous, as we look back, that it was not immediately accepted and acclaimed. It is a triumph of pure clinical observation.

One of the fallacies of clinical reasoning is what is dubbed the *post hoc, propter hoc* principle. "After which is the same as because of which." For instance, just because you take aspirin and your cold gets well, it does not follow that the cold got well because of the aspirin. But Semmelweiss's proof avoided that fallacy. He had a record of the incidence of childbed fever before chlorine water was used and after. No other feature of the management of the cases was changed. His results were consistently improved over a long period of time, the more so as his insistence on the carrying out of his technique became more stringent.

For the first time, too, in the history of the discussion, with all due respect to the pioneers — Holmes, Gordon, White, and Denman — he announced a definite, clear-cut method of the spread of the contagion

and a definite, clear-cut, practical method of prevention. To Semmelweiss belongs the overwhelmingly major part of the credit for our knowledge of the means to eradicate the horrible pestilence of puerperal fever.

The reception of his ideas by his professional colleagues is one of the black spots of medical history. He is, Dr. Wiese says, "the saddest figure in the history of modern medicine." Some adherents on the faculty he immediately won. Skoda, the Professor of Medicine, Hebra, the dermatologist, and Rokitansky, the pathologist, a powerful trio, admittedly, espoused his doctrine. But Klein, his chief, and head of the obstetric department, refused to accept his ideas and soon developed into a malignant enemy. The pettiness of professional jealousy and its power for harm were never better illustrated. When in 1849 Semmelweiss's appointment expired, Klein refused his application for its extension. His election to honorary medical and scientific societies in recognition of his work simply fed the fires of his chief's resentment. Political animosities added their fuel, for Semmelweiss became an enthusiastic patriot for Hungary when his country was trying to gain her independence in 1848, and he appeared on the round of his professional duties in uniform. Petition after petition for a place on the faculty was refused him. Finally, in 1850, he was insulted by the appointment as Privat-Docent in Theoretical Midwifery, but restricted to the use of the mannikin in teaching. He was not allowed to treat patients! Heartsick and disgusted, he left Vienna without even a farewell to his friends.

In the meantime in the world at large his doctrines had a variable fortune. He gained some adherents, among university teachers, but many did not understand or appreciate the force of his ideas. Leaving Vienna, he went to Pest, where he established a lucrative private practice in obstetrics. In 1855 he was appointed Professor of Obstetrics at the University of Pest. Here again he was the object of petty faculty conspiracies, which contributed to his early break-down. In 1857 he published his most important writing, which contained the major defence of his principles, *The Prevention of Childbed Fever.*

In 1863 he was observed to have symptoms of insanity. This has often been ascribed to disappointment at the lack of acceptance of his doctrines, but it would appear that at least the last part of his illness was due to a generalized infection from a wound on his finger. He died in

an asylum in Vienna, on August 13, 1865. Autopsy disclosed the formation of pus throughout the body, with an extensive organic brain lesion.

With the advent of the era of bacteria, already initiated at the time of his death, the facts which Semmelweiss had demonstrated obtained a logical and orderly explanation. The methods of cleanliness and disinfection for which he contended became a part of all routine obstetrical technique. Puerperal fever today is almost unknown among authorized obstetricians. When a case does occur, it is considered little short of a disgrace.

Relief from pain during labour has long been eagerly sought after and is not yet a completely perfected success. The pains of labour are due to the contractions of the uterus, and it is the contractions that cause the expulsion of the child. The defect of most anæsthetics is that when they stop pain, they also stop the contractions, which are the essential mechanism of the process. The ideal obstetrical anæsthetic would be one which would shut the brain off from all sensations, but would not limit the movements of the uterus. Such perfection has not been attained.

The name usually associated with the discovery of anæsthesia in childbirth is that of the Scotch obstetrician James Simpson. He is a kindly burly figure, of peasant ancestry, who rose by his own efforts to be Professor of Obstetrics at the University of Edinburgh (1840). When ether was introduced, Simpson tried it on labour cases, but found it unsatisfactory. He began looking for some other agent.

An amusing story is told of the circumstances of his discovery of chloroform. One evening in 1847 Simpson and his assistants, Doctors Keith and Mathews Duncan, were at Simpson's home trying out the effects of various substances — the vapour of iodoform, benzine acetone, nitrate of oxide of ethyl — but with little positive result. Simpson happened to remember that a Liverpool chemist, Walde, had recommended a heavy liquid with a sweetish odour, chloroform. He located the bottle and the three men, pouring each for himself a measure of it in a tumbler, began to inhale the vapour. In a few moments they became so intoxicated that their caperings attracted the attention of the ladies of the household, who were entertaining visitors, and they opened the door of the experimental chamber. The Professor of Obstetrics in the University

was attempting to stand on his head, and his assistants were waltzing around the room laughing immoderately.

The effect wore off as suddenly as it came on. Professor Simpson awoke to find himself prostrate on the floor. His thought was: " This is better than ether."

For obstetric cases it proved to be so. For over fifty years it remained the favourite obstetrical anæsthetic.

PART VII

THE FUNDAMENTAL SCIENCE OF THE NINETEENTH CENTURY

In the nineteenth century the boundaries of knowledge were extended even more rapidly than during the seventeenth, its nearest rival among the centuries.

Biology, with the concepts of the cell, heredity, evolution, germs, calories, physical chemistry, and biochemistry, took its place among the exact sciences.

CHAPTER XX

THE CELL

One of the most magnificent sights in modern Europe is the German Museum in Munich. All human industry and the evolution of science are illustrated in its exhibits. In the section on optics there is a case which represents the development of the microscope. Every type of microscope from the flea glasses of Janssen to the latest model compound microscope is represented. Several of these are arranged so that the visitor may view a specimen on the stage. One can realize how much Leeuwenhoek could have seen, then what Hooke saw, then the binocular microscopes of Chérubin d'Orléans, the introduction of the mirror by Hertel, and, finally, the high-power, oil-immersion lens familiar to every presentday physician.

The increase in the clarity with which tinier and tinier details come into focus is a good example of the fact that scientific advance waits on the perfection of the instrument.

In our narrative we left the early microscopists — Swammerdam, Leeuwenhoek, Malpighi, and Wolff — working with their simple instruments, able to make out some structures which could not be seen with the naked eye — capillaries, spermatozoa, the little animals in the mouth, the red blood-cells, the beginning of organs in the developing animal. They could discover no more because they could see no more.

It was in 1812 that William Hyde Wollaston put two plano-convex lenses at a certain distance apart, the "Wollaston doublet." Brewster, Coddington, and Herschel also made improvements, and finally, in 1830, Joseph Jackson Lister, father of the greatest surgeon of all time, reported to the Royal Society the technical details necessary to construct successfully a perfect compound microscope.

These technical advances soon had results.

In October 1837 two young men met in a café in Berlin to enjoy a dinner and chat together. One, Schleiden, was a student of botany at the university; the other, Schwann, was assistant to the Professor of Physiology, Johannes Müller.

Naturally they fell to discussing their common interests in natural science.

"I have been much interested in the microscopic structure of plants," said Schleiden, "and especially in what I conceive to be the ultimate units of structure — cells. They were observed by Robert Brown and Hooke long ago, but with our more powerful microscopes I think I have seen something which they could not see."

It was obvious that his colleague was immensely interested.

"Each cell has a nucleus," continued Schleiden. "Small, sharply defined granules are first generated in a granulous substance, and around them the cell nucleus is formed. These grow for a certain time, and then a minute transparent vesicle rises upon them, the young cell, so that in the first instance it is placed upon the old cell like a watch-glass upon a watch.

"All cells," he concluded, "all vegetable tissues, grow by the multiplication of individual cells."

Theodor Schwann nodded. He was not surprised.

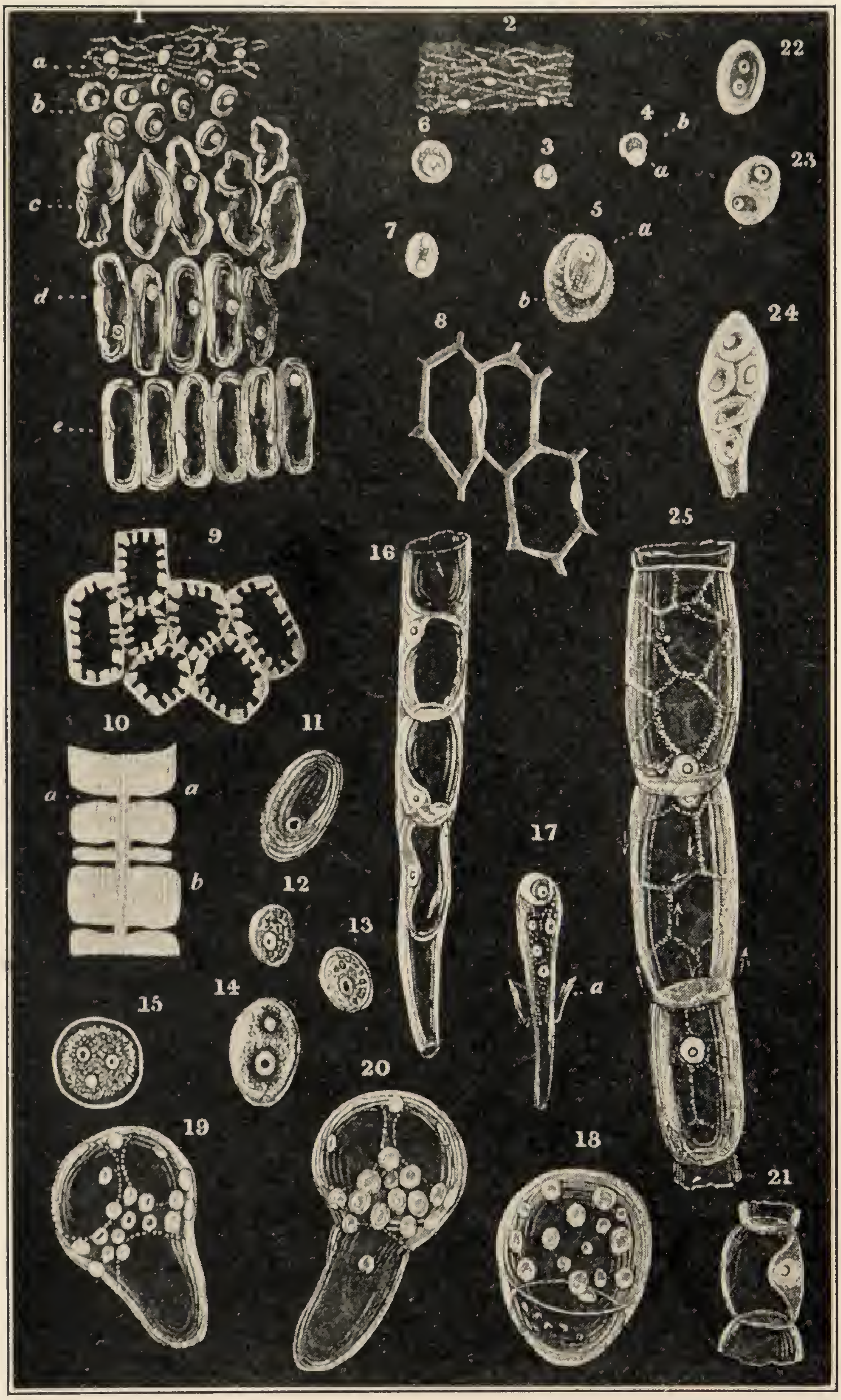
"So do animal tissues," he said confidently. "I have seen them and so has Professor Müller in the chorda dorsalis of tadpoles. Although," he added generously, "I had not thought of it in quite such clear terms as you have just expressed."

"Let us go to your laboratory and see them," cried Schleiden, and the two enthusiastic young men left their dinner and spent the evening in each other's laboratories.

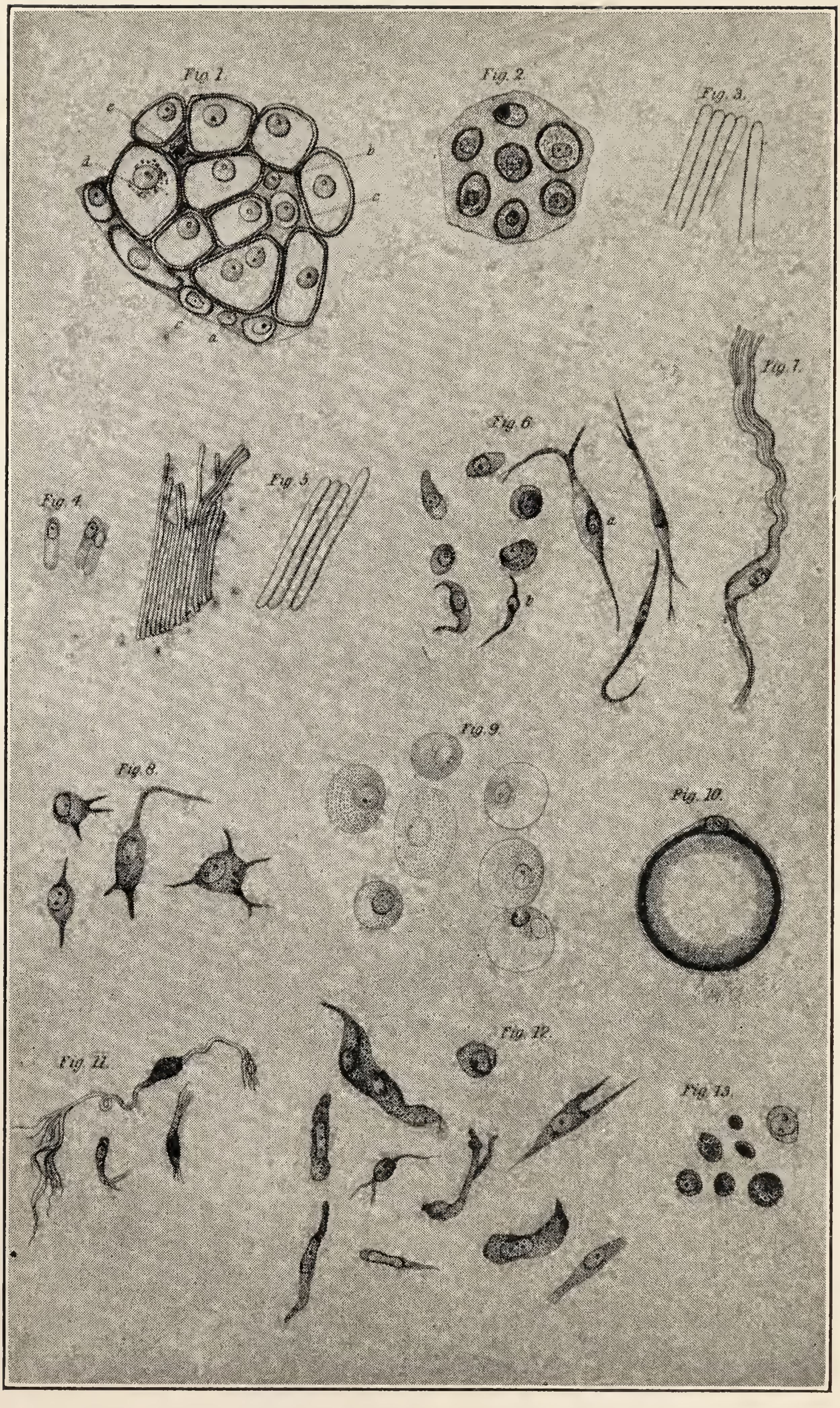
When they were finished, they agreed perfectly. Vegetable and animal tissues were essentially, ultimately, the same thing — cells.

In 1838 Schleiden announced the generalization to the world in a paper on *Phytogenesis*. In 1839 Schwann published his paper *Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants.*

The cell theory was established — the fundamental generalization of all biology. The cell is to biology what the atom is to chemistry, what energy is to physics.



Schleiden's pictures of plant cells.



Schwann's pictures of animal cells.

Soon the entire body was thought of in terms of different kinds of cells.

The greatest of the new generation of microscopic anatomists — the founder of the new science of histology — was Jacob Henle. He was a Jew, born in Fürth, near Nuremberg, in 1809. After his graduation in medicine he became Professor of Anatomy at Zürich. While with Müller in Berlin, he defined epithelial tissues and proved that they cover the outside of the body in the form of the skin and, further, that they line all the internal cavities — the mouth, the stomach and intestines, the bronchial tubes, the bladder, the vagina, etc. In 1840 he showed that a certain kind of muscle — smooth muscle, not under voluntary control — was the middle coat of blood-vessels and the contraction or relaxation of these involuntary muscle cells made the differences in blood-pressure, in the flushing and pallor of the countenance, in warmth and cold of the feet and hands. The exact internal structure of the kidneys, with their minute loops and tubules, was also his elucidation.

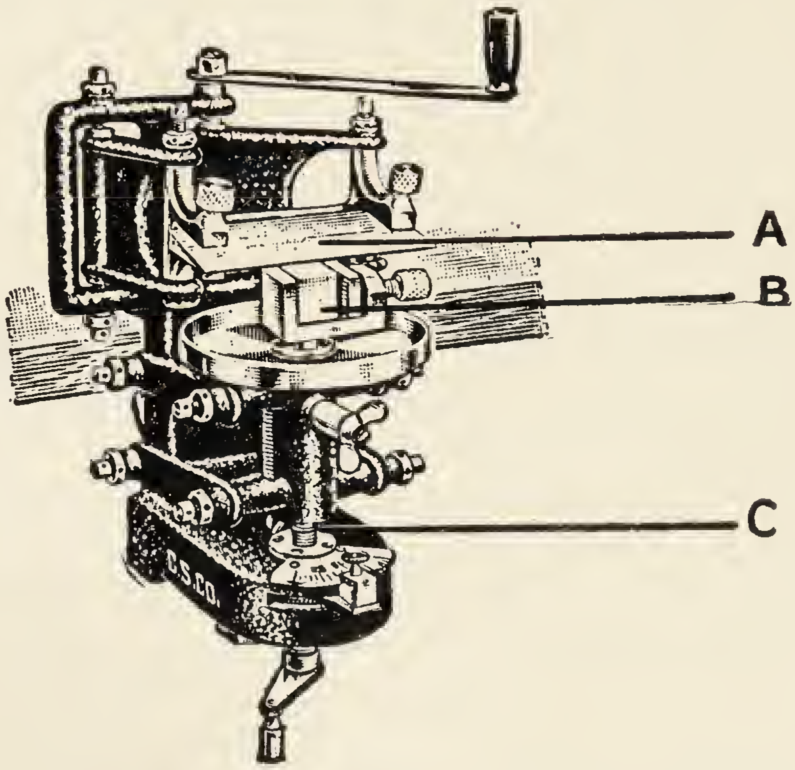
Another addition to the technique of the new science of histology was the invention of the microtome by the Swiss, Valentin, and perfected by the Bohemian, Purkinje. When Purkinje was appointed Professor of Physiology at Breslau, in 1823, he asked that his department be supplied with a microscope. The authorities were much annoyed. The thing was unheard of. Why couldn't the young man go on lecturing on physiology like his predecessors? But they gave it to him, and then he established a laboratory. The whole faculty objected to this, especially to its stench. Such was the academic attitude then.

The microtome is an instrument for cutting animal and plant tissues into very thin transparent sections. The long blade, of razor sharpness, glides on a solid track, and the tissue to be cut is hardened and embedded in paraffin — more often, nowadays, frozen — and then the block is moved into range of the sharp blade by a screw with such fine threads that only the thinnest shavings result. Methods of cutting these thin slices of tissue and of staining them with various dyes so that the different parts of the cell are contrasted greatly advanced the new science of cellular structure.

Now it was possible, too, with these new methods to determine with more exactness the development of the animal from its earliest formation. This department of anatomy — embryology — owes more to Carl Ernst von Baer than to any other single worker.

The individual begins as a single cell — a cell which results from the union of the mother's generative cell (the ovum) and the father's generative cell (the sperm).

After this union, which is an event unique in cell life, the new cell begins to divide very rapidly and the new cells so formed spread out into three layers. Each of these germ layers consists of undifferentiated embryonic cells, but each somewhat different from the cells in the other layers. From each there develops a definite set of organs of the mature animal body. From the upper layer, the ectoderm, there develop the skin and mucous membranes of the mouth, nose, and rectum, and the entire nervous system, including the eye. From the middle layer, the mesoderm, there develop the connective tissues, the bones, the muscles, and such internal organs as the heart, blood-vessels, blood and marrow, kidneys, and organs of reproduction. From the lower layer, the endoderm, develop the lining of the digestive tract and the glands which shoot off from it, the liver and pancreas, the lining epithelium of the larynx, trachea, lungs, bladder, and urethra.



Microtome, modern design. Its purpose is to cut tissues into slices so thin that they are transparent and can be examined readily under the microscope. The cutting blade at A. The block of tissue B. At C an accurately cut screw raises the tissue block a microscopic distance towards the knife so that a new slice can be cut at the next sweep of the blade.

This germ-layer theory was first suggested by Christian Pander in

1817, prophetically foreshadowed by Wolff, but it was von Baer who, in his classic *Development of Animals,* published in 1828, gave the conception the rank of a general law of biology — von Baer distinguished four primary layers. Remak (1815–65) showed that this was based on the fact that the mesoderm consists of two layers, in reality of identical nature.

This new birth of anatomy in the first half of the nineteenth century — the revelation of this cosmos in little, millions of intricate processes going on all about us, too minute for our earthly eyes to appreciate, vibrated the whole structure of thought. Two majestic generalizations in biology followed closely — the conception of organic evolution and that of heredity. Both have their ultimate explanation in the cell. There is not space nor need here to describe their history: it has been well done elsewhere.

But upon the immediate concerns of medical science these ideas had an equally potent effect. Cellular pathology and bacteriology sprang also from the new technique of the microscope. And with them we must, perforce, deal.

CHAPTER XXI

DISEASE CELLS

Huns!"

Thus Armand de Quatrefages characterized the Prussians. He was labouring under somewhat justifiable excitement and perhaps forgot that he was an eminent ethnologist. The excitement was due to the Prussian shells which had fallen upon the Natural History Museum of Paris and had destroyed many of Quatrefages's precious specimens — skulls, teeth, weird clothing from the ends of the earth. The year was 1871 when the Prussians got uncomfortably close to Paris. So close that they captured it.

"Huns!" That is what he called the Prussians. And it was not the mere idle rhetoric of an outraged citizen. It was the dictum of one of the greatest ethnologists in the world — a profound student of racial characteristics.

Nor was that all. He did not content himself with a mere oral pronouncement. He wrote a pamphlet. In the pamphlet he stated that the Prussians were not Germanic at all, not Nordic, not Teutonic. They were Mongols. Barbarians! Destructive in character, not constructive. Huns!

The Professor of Pathology at the University of Berlin read this pamphlet and went white with anger. He was not only a Professor of Pathology; he was also an anthropologist, one of the best on earth. This from Quatrefages! By God, a considered opinion by a scholarly research worker in anthropology. So fumed Rudolf Virchow. He took it very seriously.

Among his many activities, Virchow was a member of the Prussian House of Delegates. He would show this insolent Quatrefages. He introduced a bill allowing him to examine all the schoolchildren in Prus-

sia by anthropological measurements in order to prove that their cranial and other racial characteristics were not Mongolian. Huns, indeed! He would gather scientific proof.

So this scientist-statesman started out to examine his schoolchildren. He would examine enough of them — all, if necessary. They were the units of the State — just as cells were the units of the body. He and his commission examined them — six million of them. They stood in line. Their heads were measured with calipers from end to end, and side to side. One of the hairs on each head was pulled out and put under a microscope; their teeth were looked into and dictation about them shouted by stern-faced physicians to busy secretaries. The children thought Heaven knows what was going to happen. Perhaps this Prussian State was going to throw away or drown the imperfect ones. They had not heard of the Musée d'Histoire Naturelle in Paris with the hole in the roof and the pardonable Gallic excitement of the non-Mongolian ethnologist.

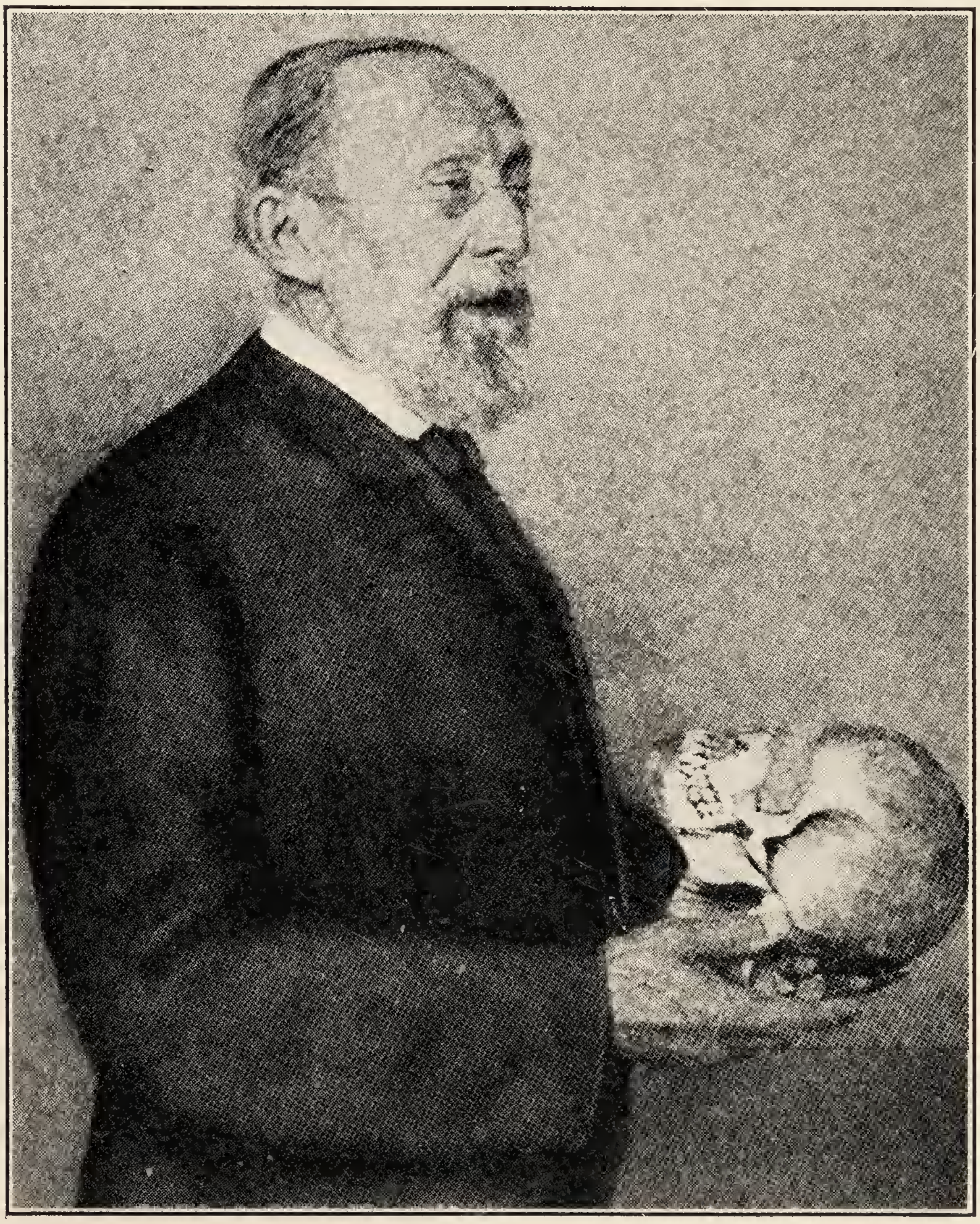
And finally it appeared that the Prussians were not Huns at all. They were just like the French — only more so.

That was Rudolf Virchow's way. He did not like theories, or wild statements such as Quatrefages made. He wanted facts. And he liked to think about complex things like the State or the human body in terms of their ultimate units, citizens and cells.

When anything was wrong, it was because some of the ultimate units were disturbed. This idea must have been implanted in him early in life. When five years out of medical school, in 1848, he was sent by the Prussian Government to Silesia. There was an epidemic of fever raging among the weavers there. The Government called it "famine fever" and wanted Virchow, who was known already as a brilliant and thorough investigator of disease, to determine the cause of it.

But Virchow knew of no famine fever. Furthermore, he despised theories. Most of his fame had come from a slashing attack upon the theories of Carl Rokitansky, the Professor of Pathology at Vienna. Virchow jumped on Rokitansky's theory that diseases were due to disturbances of a primitive blastema — crases and stases. Under Virchow's attack this appeared as mere moonshine. The young man of facts called Rokitansky an anachronism. After he had read Virchow's critique, Rokitansky could never again look at the first edition of his book where these theories appeared.

It was facts, solid facts, young Virchow liked wherever he went, and he found them in Silesia. They were not pleasant facts. These weavers — these suffering men and women — were citizens of the great Prussian State, yet the State had neglected to provide even the most elementary protection for their welfare. Hence they were sick, and since



Rudolph Virchow (1821–1902).

they were sick, the State was sick. The sickness they had was no vague famine fever. It was typhus fever, due to filth and stinking living conditions. That is what Rudolf Virchow found and so he wrote in his report to his Government.

He went to the root of things. Not only must they clean the houses of the weavers, they must clean the houses of the Government. Not only

must they drive out the rats, they must drive out the councillors. They must build a clean State — a democracy.

Such frankness is unexpected in young scientists, sent out quietly to submit a sober study of a social and hygienic situation. Dr. Virchow was removed by the Government which had appointed him — he was relieved of his prosectorship in the university and set adrift. He did not drift long. The University of Würzburg was anxious to obtain so promising a young man. They offered him the chair of Pathological Anatomy there, and Virchow accepted. He returned, however, to the chair at Berlin in 1856.

But his political experience had taught him something. At Würzburg he began to think of the human body in terms of the State. What made the State happy? The prosperity of each individual citizen. What made the body healthy? The health of each of its units — its cells.

The time was ripe for thought of cells. Schwann and Schleiden had shown that every animal and every plant were made up of these individual cells, about ten years before Virchow went to Würzburg. Henle had shown how the cells were arranged in different parts of the body, and how different tissues — those tissues Bichat had described — were different simply because they had different kinds of cells — epithelial cells made epithelial tissue, and muscle cells made muscular tissue, etc.

What is the real nature of disease? This was Virchow's haunting question at Würzburg. He had means to go behind the things which Morgagni and Baillie saw. He had the microscope. Where they found only a clot inside a blood-vessel he could cut that clot and blood-vessel across into thin strips with the two-bladed razor invented by Valentin, the Swiss professor, and Purkinje, whom Goethe had had installed at Breslau. With these strips cut so thin that they were transparent, and stained with methylene-blue, the ultimate structure of diseased tissues could be seen under the microscope.

What *was* seen? Cells. Just as normal tissues were made up of cells, so diseased tissues were made up of cells. And diseased cells were no different from normal body cells. They were exactly the same cells. They were only arranged a little differently, or shrivelled a little, or degenerated, or actually dead. Just as those weavers in Silesia were just the same as any other citizens of the Prussian State, only more crowded, weaker, less active, more resentful.

Diseased tissue was made up of the same elements as healthy tissue.

Here was an abscess — a minute abscess in the lung. When you cut across it and looked at it with the naked eye, it was a white, malignant, unnatural-looking thing. But when you cut it into thin slices and put one under the microscope, you found it was made up of thousands of cells — the white cells found in normal blood. The only abnormal thing was that they were displaced and crowded together in one spot.

A cancer of the skin — what did it look like? It was made up of thousands of cells — they did not look, as did the cells in the lung abscess, old and tired, but appeared to be fresh and vigorous. But except for this they were just like the neighbouring skin cells. When teased out and isolated, they could not be distinguished from the skin cells. They must have sprung from them.

Now, if you took some of those lymph glands which were enlarged near a cancer of the skin and sectioned them, what did you see? They were also filled with cells — skin cells — exactly like the cells which made up the cancer and like the cells of the normal skin near the cancer. That was the way cancer spread through the body and caused death — the cells of the cancer were carried from the original site by the lymph and spread from one lymph node to the other and into other organs. These secondary implantations were the metastases, so called.

Then suppose one took a section from a healing wound. You saw different things at different stages in the process of healing. But always you saw cells poured out to help the healing — cells which were split off from near-by cells in the tissue where the wound occurred. These new cells would build up the gap caused by the wound and fill the open space and make everything as good as new.

Those were the things Rudolf Virchow saw in diseased tissues under the microscope.

And so he announced his great doctrine: "*Omnis cellula e cellula*" — "All cells come from other cells." Disease cells originate in normal body cells. The body, he said, remembering his Silesian experience and his brooding on society and government — the body is "a cell state in which every cell is a citizen." Disease is the "conflict of citizens in this state, brought about by the action of external forces."

There was one thing which greatly puzzled him and which he had to clear up before he wrote his book. Those small abscesses in the lung — how did they get there? Why were they all alike all over the lung? If they were all made up of the same kind of cells, they must all come from the same place.

And equally those cancer cells in the lymph glands — clear away from the cancer itself. How did they get there?

When he was examining the bodies which had these small lung abscesses, he found many veins full of clotted blood. Everybody knew about those. Thrombi they were called. Cruveilhier, the Frenchman, said all inflammation was due to this coagulation of the blood in the vessels. But Virchow could show that was not so. There was lots of inflammation without a thrombus. Cruveilhier answered that there was minute capillary clotting in these cases. That was all very well in the days of Cruveilhier's youth, but Rudolf Virchow had good microscopes and good tissue sections and he could show that there was no capillary coagulation in these cases of inflammation. Stick to the facts. " An unproved hypothesis of any kind is a very leaky bottom for practical medicine to sail or trade upon," he had announced in one of the first of those " manifestoes of the modern spirit in medicine," in his own magazine.[1]

He began to find out what the facts were. He noticed that there were many kinds of thrombi. There were always thrombi when multiple abscesses appeared in the lungs. But the thrombi when the lung abscesses were present were different from the thrombi when the lung abscesses were absent. He pointed out that they had a central core of liquefaction. This liquefaction was white — like the abscesses. And when he put the thrombi with the white liquefaction under the microscope, it was made up of the same kind of cells that made up the lung abscesses.

Well, then, these white thrombi moved through the veins until they got to the lungs. The lung capillaries were so small that the thrombi were stopped in them. And the putrid matter from a distant part of the body destroyed a healthy part of the body.

Main travelled roads! The body again was like a state — made up of thousands of roads. If a weaver left a plague-infected village in Silesia and travelled to another village, soon the plague broke out in that previously healthy village.

Well, all that was plain enough. The body was a living, active organism. Particles of diseased matter broke off from a septic clot in one vein, moved in the blood-stream all over the body. Virchow showed they could be washed off the valves of the heart. He called them emboli. " Pyemia, a mystery to physicians from the day of its recognition, was a simple consequence of transfer of solid particles from one inflamed

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[1] Quoted from Garrison's *History of Medicine*. Virchow's magazine was the *Archiv für pathologische Anatomie*.

region to another point by the direct path of the blood stream, or, in Virchow's term, embolism."[1]

So those cancerous inclusions in distant lymph glands were due to cancer cells getting away from the site of origin and wandering out into the lymph spaces and setting up growth of their own. They were also emboli, but a special name was given them — metastases.

Thus when, in 1858, Virchow published his book *Cellular Pathology,* a new era in the study of diseases was inaugurated. Disease was a perfectly natural phenomenon, obeying the laws of the body, developing by perfectly understandable and discoverable means.

Virchow's *Cellular Pathology* stands with Vesalius' work on anatomy, with Harvey's work on physiology, and Pasteur's work on bacteriology, as one of the four foundation-stones of medical doctrine.

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[1] Long: *History of Pathology.*

CHAPTER XXII

GERMS

One final conquest of the realms of darkness remained to be made in the nineteenth century.

Morgagni and Hunter and Virchow had shown the nature of disease, but one great question stood unanswered. What is the cause?

Here is a perfectly healthy body. Suddenly it becomes a diseased body. Virchow said the cells became disarranged. Yes, but what caused the cells to become disarranged? Why did John's cells become disarranged and James's cells — James, who lived in the same house — not become disarranged?

Tuberculosis — they knew lots of kinds of tuberculosis. There was tuberculosis in the lungs, and tuberculosis of the bowels, and tuberculosis of the bones. When they put all these different kinds of tuberculosis under the microscope, they all looked alike. There was the same grouping of cells — called the tubercle — in each of them. In spite of the diversified structures which tuberculosis attacked, the unity of tuberculosis itself was unquestioned. Wherever it was, it was the same thing. But what caused it? Nobody knew. Everybody speculated, but nobody knew.

Almost in the very year that Rudolf Virchow's epoch-making *Cellular Pathology* was published, the answer was beginning to be found. In the city of Lille a very modest humble-minded chemist, named Louis Pasteur, discovered that one kind of tartaric acid (which deflected a beam of light to the left) could be made from another kind of tartaric acid (which deflected a beam of light to the right) by putting yeast in it.

Pasteur's story has been told so often and so eloquently that one hesitates to add any other account to those already recorded. But his

contribution to medical science and our present knowledge of disease processes is so enormous that he cannot be omitted.

Do not suppose that the minds of men were unprepared for the announcements he made. The general theory that diseases were spread from person to person, and from animal to animal, and from animal to person, by little animals or disease units, too small to be seen, had been often suggested. But never proved! That was Pasteur's contribution.

I find in an old and quite obscure book on venereal diseases the speculation that "little animalculæ convey the disease from one sufferer to another." It is obvious, the author argues, that the diseases are transmitted by contact, yet what actually is the disease itself? It is, he thinks, a myriad of small living organisms, too small to be seen by the eye. He recognizes that this view has met stout objection, and even ridicule, but still he can find no other satisfactory solution of his dilemma.

When Leeuwenhoek found in the scrapings from his own mouth millions of moving, tiny organisms, he was only demonstrating the actuality of these supposititious creatures — giving them a body and a form.

In Italy a century later the Abbé Spallanzani found thousands of little animals in broth and soup which had been left exposed in the air. Walter Needham, in England, said they were spontaneously generated in the broth; he persuaded even the great naturalist Buffon of the doctrine that life can arise constantly from lifeless matter. It was a ticklish moment for the science of disease. For if life can be formed from lifeless matter, and diseases are caused by a microscopic form of life, then disease can arise spontaneously anywhere. Without laws.

Spallanzani recalled the experiments of his fellow-countryman Redi (see page 197). The idea of spontaneous generation had obtained in Redi's day, too — people thought maggots grew in meat. But Redi, you remember, proved that no maggots appeared on meat that was screened from flies. No maggots without flies.

Perhaps this is true about larger and complex animals, like insects, answered Needham, but these small simple animals are of a lowly nature and form spontaneously.

Spallanzani set that idea at rest by showing that in flasks full of broth no life will form if they are heated.

Needham answered by showing that little animals appeared even in broth that was heated.

Pasteur in his laboratory.

Spallanzani replied simply by proving Needham had not heated his broth long enough and had not protected it sufficiently from the air after heating.

It was a most important controversy for science, and well that Spallanzani stuck to his guns and proved his point. He proved that the little animals caused putrefaction in broth. Putrefaction was like disease. Not until Pasteur, however, was it shown that microscopic organisms caused an actual disease.

It seemed a queer way to begin — by studying the change in tartaric acid. But remember that the change was brought about by yeast — by a small microscopic organism. Pasteur began to be interested in other chemical changes brought about by other organisms — the turning of sugar into alcohol, for instance — the souring or turning of milk into lactic acid. He showed that yeast, and the lactic acid bacilli present in the air, brought about these changes. He showed that if air were excluded, and hence yeast was excluded, the changes did not take place.

Then he began to investigate diseases — but at first they were the diseases of wine (1863). The first animal diseases he investigated were those of silkworms (1865). Then the diseases of beer (1871) and then the diseases of chickens (1877).

But everywhere he went, everything he investigated, all the changes he studied, whether of tartaric acid, of sugar into alcohol, of wine into vinegar, of live silkworms into dead silkworms — all these were due to small organisms existing in the air which dropped into the substances studied. Many changes in nature were brought about by the action of these unseen, hitherto unsuspected organisms.

"Why not human diseases?" said Louis Pasteur.

All the diseases he had ever investigated had proved to be of that nature. The diseases of wine were due to the wrong kind of organisms. The diseases of silkworms were due to bacilli, which Pasteur isolated and identified.

"Germs are all about us in the air," concluded Louis Pasteur. When they enter the body, they cause disease.

These ideas he published. They met with some objections.

The German chemist Liebig fought Pasteur on the idea that sugar turned into alcohol by the action of fermentation. Liebig thought that albumin alone would do it — the albumin in the culture medium on which the yeast grew. Pasteur answered him by growing yeast on

ammonia and then by putting ammonia and yeast and sugar together produced alcohol. There was no albumin present except in the bodies of the yeast organisms. One Pouchet, professor at Rouen, thought the organisms which grew in milk and beer and wine were spontaneously generated. That doctrine of spontaneous generation died hard.

In other minds, however, Pasteur's words were received and bore fruit. The English surgeon Lister wrote him in 1874 acknowledging that his work had been responsible for antiseptic surgery.

Despite Liebig, and despite the Franco-German war of 1870, all German minds were not closed to the Frenchman's ideas. In Wollstein in East Prussia a popular young German district physician, a general practitioner who delivered babies and bound up sprained ankles, returned from the war in 1871 and set up practice again.

His name was Robert Koch, and were it not for his work, the new science of bacteriology which Pasteur had delivered would never have grown to maturity. In fact, he deserves equal credit for its foundation.

He was twenty-eight years old and his first wife had died, leaving him with a little daughter. He married again and on his birthday his second wife gave him a microscope. Though he had only an ordinary medical education, with no training in research, and was busied with his wide general practice, he was a studious fellow, had been much impressed with the new ideas of germs causing disease, and was delighted with his microscope because he had an itch to try to see some of these little germs himself.

Animals are easier to work with than human beings, so Koch started out on anthrax, a disease which had destroyed thousands of sheep in his own district. It was contagious — passed from sheep to sheep, decimated whole flocks. Evidently it was due to a germ. Indeed, a French scientist, Davaine, had demonstrated germs in the blood of the dead animals. They were chains of long rods — anthrax bacilli.

But there were many puzzles which this simple finding of germs did not explain.

Professor Cohn, who held the chair of botany at the University of Breslau, had formulated them. Bacteria were adjudged to be plants; therefore, they fell under the study of the chair of botany. Professor Cohn had proceeded to the study of them with great enthusiasm, and his scientific mind had defined the difficulties clearly and coolly:

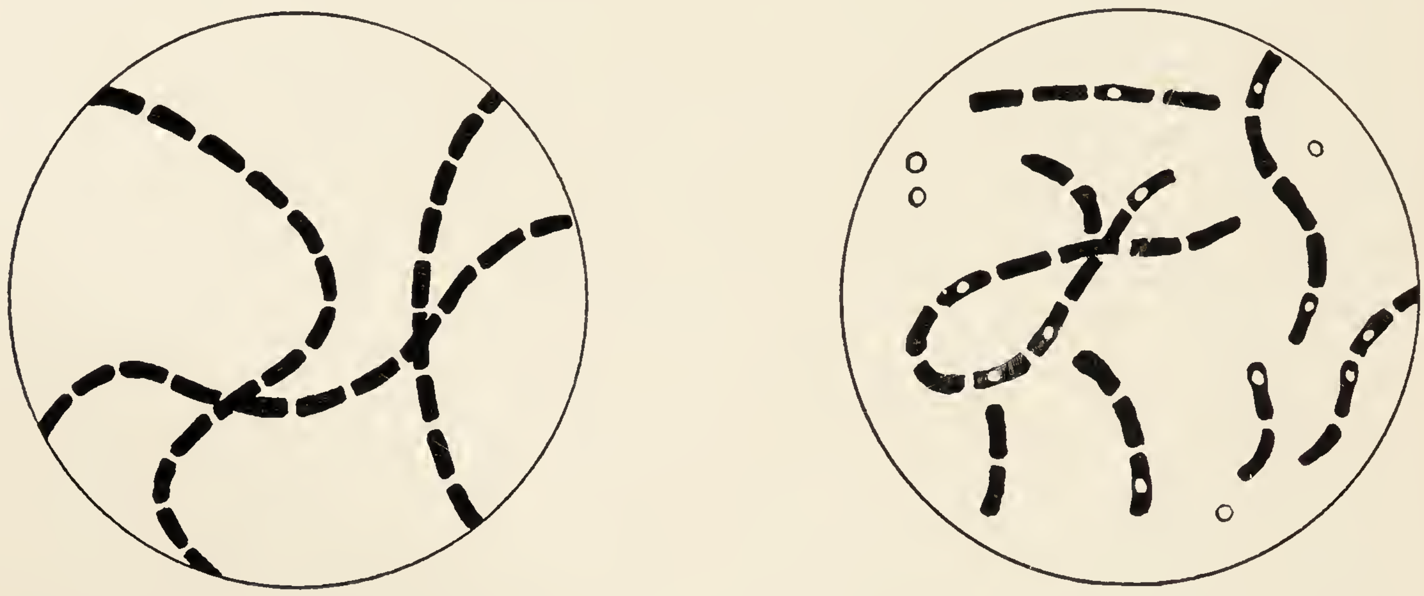
Why was it that you could take the blood of an animal sick with

anthrax and show that it contained no anthrax bacilli under the microscope, but still, when it was injected into a healthy animal, anthrax developed?

Why does anthrax break out in regions where no living anthrax bacilli can be found?

Koch rigged up his own apparatus for his microscope and was able to identify anthrax bacilli clearly enough. But then he struck snags. One was experimental animals. He was busy with his practice and couldn't have sheep around the house.

So he tried mice. He found he could kill a mouse by injecting blood from an infected sheep into it and recover anthrax bacilli from its liver and spleen. But the worst snag was this: he could take blood in which



Appearance of active growing culture. *Appearance of resting stage with spores (the white oval spots).*

The anthrax bacillus.

he could see no anthrax bacilli under the microscope and inject it into a mouse, and soon the mouse would die and millions of anthrax bacilli would be found in the spleen.

He had to think awhile about that. And think hard. But why not, he said, suddenly — Of course! How stupid not to have seen it sooner! The bacilli are living things, aren't they? If they are living things, they multiply. He could not *see* any anthrax bacilli in the blood of the sheep because they were so few, but when they got into the body of the mouse, they multiplied and those were the millions he saw in the spleen.

That was all right for speculation. But how about proof? Science is demonstration, not speculation.

Then the best, the finest thought of all. If they multiply in the body,

couldn't they be made to multiply outside the body? Couldn't they be cultured outside the body? In some fluid which resembled animal chemical reactions, and was kept at the same temperature as the animal body. Then they could be watched in this fluid under the microscope to see whether they multiply.

He selected the fluid in the eyeball of an ox as the medium which might serve to promote the growth of the bacilli. It had the advantage of being transparent, so that he could watch the process under his microscope.

Then he invented the hanging drop microscope slide — a glass slide with a little pit in it over which another thin piece of glass could be placed, enclosing his ox-eye fluid with the bacilli.

He was ready to watch then, and sure enough, under his eyes, from one or two sprang long chains of millions of germs — glistening refractile rods.

So there was the explanation of how apparently bacilli-free blood from a sick sheep could cause anthrax when injected into a healthy sheep.

Crudely fashioning his own apparatus, he constructed the first incubator — with an oil lamp — a box where the temperature could be maintained at the proper level for bacterial growth. Here he could leave ox-eye fluid and beef broth inoculated with anthrax bacilli and thus he could grow pure cultures of the bacilli outside any animal body and inject them into sheep and mice and produce the disease.

It usually puzzles outsiders when they hear that the first germ diseases to be studied intently were animal diseases. But it was probably the luckiest thing that ever happened for the human race that Pasteur and Koch began on them — because of the experimental material. They could sacrifice animals and get at the real truth, whereas if they had started on an exclusively human disease, they would have been balked at every turn.

Now he was ready for Professor Cohn's other puzzle: Where did the anthrax bacilli go between epidemics?

Here, all of a sudden, in a wholesome pasture, the sheep will begin to fall sick of anthrax.

Pasteur thought earthworms brought it up to the surface of the ground.

One day Koch, in his home-made laboratory, studying an old dry

culture outside the incubator, found his bacilli present when he peered at them under the microscope, but they had assumed a curious appearance — they had little beaded swellings at the end of each bacillus. Were they dying from the drought and cold? He tried to culture them again. And they grew! They turned into normal, fine, lively bacilli.

Those little beads were the resting stage — assumed so that they could resist cold and heat and sunlight and dryness. Spores, he called them.

So now he was ready. He had the complete life-history of the organism which caused one specific contagious disease.

He wrote to Professor Cohn. That generous-minded scholar, though perhaps skeptical, arranged an opportunity for him to demonstrate his discoveries. At the Botanical Institute at Breslau in April 1876.

Professor Cohn had invited a distinguished audience. Julius Cohnheim happened to be Professor of Pathology at Breslau. He had studied under Virchow and, after Virchow, was the most distinguished investigator of cellular pathology in the world. He had established in 1861 the cellular mechanism of inflammation. Associated with him at the time was Carl Weigert. In 1871 Weigert had first stained bacteria with dyes so that they could be seen more readily under the microscope. Auerbach, the anatomist, who had described the nerve plexuses in the intestines; Traube, the Professor of Medicine, who first recorded a continuous fever chart — all these were in the audience of the humble country practitioner.

As the demonstration went on — as one solid indisputable fact, proved up to the hilt, was followed by its logical successor — the coolness of the audience changed to interest, then to ungovernable enthusiasm.

Cohnheim rushed out of the room and into his own laboratory. "Drop everything," he cried to his assistants, "and go at once to Koch. This man has made a splendid discovery. He has produced something absolutely complete."

Koch had produced at one birth the method of cultivating bacteria outside the body, the inoculation of animals with pure cultures, the fundamental bacteriologic methods of the incubator and the hanging drop.

"I consider this the greatest discovery in the field of bacteriology," Cohnheim told him, "and believe that you will again astonish and shame us with still further discoveries."

He was a true prophet. Koch probably learned from Weigert in Breslau how to stain bacteria, and soon he was improving on the original method, demonstrating flagella, photographing them, showing how to dry and fix them on cover slips and then stain them.

Cohnheim and the others helped him to a more secure financial status. He was made district medical officer at Breslau and then appointed to the Imperial Health Office in Berlin (1880). His financial worries were thus resolved.

Modern bacteriology introduced to the scientific world. Robert Koch, a countrified young practitioner, demonstrating the life-history of the anthrax bacillus to the faculty of the University of Breslau.

In 1878 he published a study far more important to mankind than his work on anthrax — the study of wound infection. Pasteur had previously seen some little microbes in boils. Koch named them, demonstrated methods of identifying them, and proved their relation to all septic processes.

Pasteur's "*microbe en amas de grains*" was christened by Koch our familiar staphylococcus — the pus-producer. Pasteur's "*microbe en chapelet de grains*" became our streptococcus — the sepsis-producer.

Here was the explanation of Semmelweiss's observations. Childbed

fever, the peritonitis, the "cadaveric poison," were caused by the entrance of the streptococcus into the open bleeding surface of the womb and birth canal. His chlorine water killed it off.

Here was the complete minute explanation of Lister's true clinical observations. His compound fractures and other wounds were contaminated with staphylococci and streptococci. That was why they suppurated and became gangrenous. That was why his carbolic spray and carbolic dressings worked so well. The carbolic acid killed these germs. So, too, that was why Spencer Wells and Lawson Tait got good results from simple cleanliness — soap and water will get rid of germs also.

One important discovery after another was announced in these crowded years. The cause of leprosy was demonstrated as a bacillus in 1871 by Hansen; the cause of gonorrhœa by Neisser in 1879; the cause of typhoid fever by Eberth in 1880; the causes of the pneumonias by Pasteur, Sternberg, Fränkel, and Friedlander in 1881 to 1883; of tuberculosis by Koch in 1882, of diphtheria by Klebs in 1883; of lockjaw by Nicolaier in 1884; of meningitis by Weichselbaum in 1887; of malaria by Laveran in 1880; of syphilis by Schaudinn in 1905. A host of co-workers and associates made other less important discoveries. There is glory enough for all.

What these discoveries have done for the comfort of mankind and the peace of men's souls is incalculable. Pasted on the fly-leaf of my copy of Wells's *Outline of History* is a newspaper clipping of unidentified date and source. It states that Dr. E. E. Free, a fellow of the American Association for the Advancement of Science, gave as his opinion that the ten greatest scientific discoveries in the history of the world were as follows:

The discovery that animals can be trained.

The discovery that useful plants can be made to grow artificially by planting their seeds in the ground.

The discovery of the principle of the knife.

The discovery of copper.

The discovery of the wheel.

The discovery of business credit.

The discovery of coal.

The discovery of printing.

The discovery of the electric dynamo.

The discovery of the germ theory of disease.

For purposes of debate let us accept this list and note that only the last three discoveries were made within the historical period and that one of these three is the discovery we are here recounting.

See what the researches I have mentioned did for the science of disease. Tuberculosis, for instance. We have noted that tuberculosis would attack various parts of the body — the lungs, the intestines, the kidneys, the bones. Also that, no matter where it lit, a peculiar tissue change occurred — the tubercle. The unity of tuberculosis was established on the basis of this tubercle. But it was a rather shaky foundation before Robert Koch discovered the tubercle bacillus. Then, with the cause known, the decision as to whether a diseased piece of tissue was tuberculous or not was made by determining whether the tubercle bacillus was present or not. Patients suspected of having tuberculosis of the lungs could be finally adjudicated by whether the sputum contained tubercle bacilli. Patients with other diseases — tuberculous peritonitis, for instance — could be classified by injecting some of the suspicious material into a guinea-pig and observing whether tuberculosis developed in the guinea-pig. It opened up a whole new science of tuberculosis, which at the time of Koch's discovery of its cause was the most destructive disease in the world.

The discovery of the organisms responsible for wound infection opened the way for safe and scientific surgery and obstetrics.

The discovery of the diphtheria bacillus led directly to the discovery of the antitoxin to cure diphtheria. It also provided a means to identify immediately any sore throat definitely as diphtheria or definitely as not diphtheria — by making a swab and culture of the throat and examining it under the microscope. Before the discovery of the diphtheria bacillus by Klebs, and its isolation by Loeffler, the mortality from diphtheria was 40 per cent; now, taking all cases, early and late, including even those where fear and prejudice prevent the use of antitoxin, the mortality is 5 per cent. In 1890, just before the introduction of antitoxin, there were 112.6 deaths from diphtheria per 100,000 population in the United States; in 1900, when antitoxin had been in use seven years, this had dropped to 43; in 1920 to 16, and in 1927 to 8. The introduction of the Schick test gave us a means for determining whether a child is susceptible or immune to diphtheria; the toxin-antitoxin mixture gives us a means of rendering susceptible individuals immune. Diphtheria is the supreme example of man's complete conquest over one aspect of

external nature — a part of nature essentially malignant and inimical to him.

The discovery of the typhoid bacillus as the cause of typhoid fever was not lightly established. An opponent of Eberth drank a typhoid stool in the presence of his class of medical students in order to establish his belief that they were not infectious. But the truth prevailed over such dramatic spectacles. The final agreement as to the cause of typhoid fever led to the development of the most completely successful measures for the protection of the public health we have. With the cause of typhoid fever established, the method of its propagation could be decided; with the knowledge of how to recognize it broadcast, every suspected sample of water from a public water-supply could be finally judged. And those which were contaminated could be cleaned up. In 1900 the death-rate from typhoid fever on the average was 35.9 per 100,000 population; in 1927 it was 4.8. This change, as well as the change in the mortality from diphtheria, was directly the result of the discovery of the cause.

The discovery of the cause of malaria by Laveran led to the discovery by Ross that the disease was transmitted by mosquitoes and to Grassi's practical plans for the prevention of its spread.

The discovery of the cause of syphilis led directly to the preparation of the so-called 606 of Ehrlich for its treatment. Without knowledge of its cause the preparation of the drug would have been impossible.

The discovery of the cause of spinal meningitis by Weichselbaum led to the preparation of an effective anti-serum by Flexner.

The discovery of the cause of lockjaw led to the preparation of a method of prevention — tetanus antitoxin.

CHAPTER XXIII

THE NEW PHYSIOLOGY

In 1847 a young man, named Joule, who had been neglecting the brewery business in Manchester because he wanted to let bricks fall from second-story windows into buckets of water, read a paper on the subject before the British Association for the Advancement of Science at Oxford.

He said that the water stopped the fall of the bricks, but that the fall of the bricks warmed up the water.

That was his paper. It didn't seem very bright, and none of the lions of the intellect assembled bestirred themselves to discuss it, until another young man, named William Thompson, rose and pointed out that this meant that heat was a form of motion.

Heat had generally been considered as a substance — phlogiston. When wood burned, the ash was lighter — the phlogiston had left, explained the theorists. But Joule's bricks didn't lose anything except motion. Yet the water got warmer. The water had picked up the motion from the bricks and converted it into another motion — heat. Change the word "motion" to "energy" and you have mechanical energy converted into heat energy. Joule showed that the more mechanical energy there was — that is, the farther the brick fell — the more heat there was. The doctrine is called in physics the mechanical equivalent of heat.

In the same year of 1847 four men in Berlin deliberately set about discussing what was needed to round out the science of physiology. They decided it was a unifying principle. Here were a lot of things about the body understood well enough. The heart beat and circulated the blood. The stomach and other digestive organs converted food into nutriment, and the lungs contracted the necessary oxygen from the air,

and the muscles moved in response to nerve impulses. But all these things had been analysed from the observation of a complicated and unified organism. What made all these wheels go round?

The four men were Helmholtz, Ludwig, Du Bois-Reymond, and Brücke. They assumed that animal bodies were not different from other things in nature. Our bodies produce heat, as furnaces and other

Statue of Joule at Manchester.

machines do; everyone knew that. Du Bois-Reymond had shown (1843) that in a contracting muscle there is a change of electric potential. So electricity as well as heat is produced in the body. Heat and electricity are forms of physical energy. Consideration of these facts indicated that ordinary physical changes went on in the body. Physiologic activity certainly produced chemical changes. The four men decided that animals were physico-chemical machines.

Their task, the task of the new physiology, was to prove it. That was

to be the unifying principle. Some preparatory work had been laid down.

The most profound intellect in that group was Helmholtz's. In the same year, 1847, he announced his great generalization of the conservation of energy. This idea encompassed Joule's mechanical equivalent of heat and stated that all forms of energy — motion, heat, light, electricity, sound — were convertible the one into the other with absolutely no loss. These physical principles of Joule and Helmholtz were to be applied immediately to the new conception of the physiology of the body.

In France one of the greatest physiologists of all time, Claude Bernard, had already established some of the chemical principles of life. In 1843 he discovered that cane sugar injected into the veins appears in the urine, but not if it has been acted upon previously by the digestive juice of the stomach. He became interested in sugar in the body and found that the vein going to the liver was full of it. This led to the discovery of the glycogenic function of the liver. The liver converts sugar prepared from food, by digestion, into a form of fuel — glycogen or animal starch — which can be utilized by the body. The energy — muscle movement and heat — of the body arises from the burning of glycogen.

Later, by his researches on the function of the pancreas, Claude Bernard established our modern theory of digestion. Before him all digestion had been considered due to the action of the stomach. But he said: "Gastric digestion is only a preparatory act." He showed that the pancreas has a far more rapid and powerful digestive action than the stomach. That there are three separate parts to the pancreatic juice — one digests fat, one digests starches, and one completes the stomach action on proteins and albumins.

These powerful chemical agents which convert food in the process of digestion came to be named enzymes. Their investigation was the work of Emil Fischer (from 1884 on) and Bayliss and Starling (1902). Enzymes have some remarkable properties. Fischer showed they were specific in action — that the fat-splitting enzyme of the pancreas, steapsin, digested only fats; to their appointed chemical substance they are related, he said, as a key to a door, or a glove to a hand. Each enzyme can act upon enormous quantities of the substance it is capable of digesting without being itself destroyed or even altered. In the process of change they do not unite chemically with it.

Thus the function of digestion, the investigation of which had been begun by the young American army surgeon Beaumont, was put upon a firm basis of understanding, as a chemical process.

To the physiological mind these doctrines were stimulating in the extreme. They were all related — Helmholtz's conservation, Joule's conversion, and Claude Bernard's chemical changes within the body. All nature is energy — a set of chemical and physical changes. The body is a part of nature, functioning by physical and chemical changes.

Science was gay in those days. Young Justus von Liebig and his master, Gay-Lussac, in Paris, when they had managed to create an organic chemical — one produced in nature only by living tissues — out of inorganic salts, would join hands and dance around the laboratory singing and chanting the glories of science.

"Animal chemistry" was the subject of Liebig's great book, published in 1843, even before the four physiologists met in Berlin.

"Animal heat," said Liebig, is due to the chemical changes going on in the body — the combination of tissues and food materials with oxygen. Not some mysterious endowment, note, but just the function of a machine.

The tissues of the body are merely chemicals. Their formation can be studied like that of any other chemical. For instance, *fat:*

"A spider, fierce with hunger, sucks the blood of the first fly, but is not to be disturbed by a second or third fly. A cat eats the first and perhaps a second mouse, and will kill, but not eat, a third. Lions and tigers react the same way, driven by hunger to devour their prey.

"How different from a sheep and a cow in the pasture, which eat almost without intermission as long as the sun in the heavens shines upon them!

"The herbivorous animals eat in such excess that the ingestion of starch is greater than is necessary for union with oxygen, and hence the animals fatten through conversion of starch into fat." [1]

Here was the unifying principle of the four young men in Berlin. Here they found their point of synthesis. The heart beat, the food digested, the air was respired, the muscles moved, as part of the con-

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[1] The point here is that starch and fat are composed of different arrangements of the same chemical elements — carbon, hydrogen, and oxygen — and hence starch is convertible into fat. The other primary food principle, protein, contains also nitrogen and cannot be built from either fat or starch alone.

version of energy from inorganic nature into organic life. And the veil which separated the inorganic from the organic — lifeless substance from living tissue — became more and more indefinable as you examined it.

The great central entity was nutrition. To understand it was the physiological problem of the nineteenth century.

The development of this study was largely the work of two German physiologists, Pettenkofer and Voit. Their plan was gradually evolved. They knew that the first process in nutrition was the conversion of foodstuffs into tissue — anabolism. Liebig's observation of herbivorous animals converting vegetable starch into fat is an example of that. Then there is the process of the breaking down of food and tissue into waste — katabolism. Pettenkofer observed that in a child with St. Vitus' dance who partook of an inordinate amount of apple parings, the urine contained large amounts of hippuric acid.

But what of the intermediate process — metabolism? That was the real centre. Just how did the body produce energy from sugar or fat? And how much per pound of each? How much heat was produced?

In summary, what were the units of measurement?

To determine this they must be very accurate. They must be able to measure the total amount of heat given off by an animal or a man. Not merely his temperature, but all the heat he produced. They must know the exact amounts of every chemical the body threw off while eating a certain amount of food — the amounts in the urine, the fæces, the perspiration, and, most of all, the breath. They must know the exact amount of air breathed in during a given time. And the comparative weight of the subject before and after the experiment.

To do all this, they must have a sealed chamber where the animal could stay during the experiment. Thus they could control the exact amount of air that went in, and the amount that came out, and the chemical composition of the air that remained inside after the experiment. It must be fitted with a thermometer so the heat given off could be measured.

The two investigators were in Munich, and the King of Bavaria, Ludwig II, gave them the money to construct such an apparatus. In 1861 they began their work. They could feed their subject on fat alone, or carbohydrate alone, or protein food alone, or they could starve him. They did all those things.

With what results! "Imagine our sensations," wrote Voit in his necrology of his old comrade Pettenkofer, "as the picture of the remarkable processes of the metabolism unrolled before our eyes, and a mass of new facts became known to us! We found that in starvation protein and fat alone were burned, that during work more fat was burned, and that less fat was consumed during rest, especially during sleep; that the carnivorous dog could maintain himself on an exclusive protein diet, and if to such a protein diet fat were added, the fat was almost entirely deposited in the body; that carbohydrates, on the contrary, were burned, no matter how much was given, and that they, like the fat of the food, protected the body from fat loss, although more carbohydrates than fat had to be given to effect this purpose; that the metabolism in the body was not proportional to the combustibility of the substances outside the body, but that protein, which burns with difficulty outside, metabolizes with the greatest ease, then carbohydrates, while fat, which readily burns outside, is combustible in the organism with the most difficulty of all."

As to a unit of measurement, they were able to show that foods could be measured by the physical unit for heat — the calorie. They showed that each of the three fundamental foodstuffs — fat, carbohydrate, and protein — produces a certain number of calories per gram, and that the human body, under varying conditions of activity and rest, requires quite definite numbers of calories per pound of body weight. The required amounts also vary from infancy to old age.

Thus the science of dietetics was founded.

And thus the principle which Joule discovered in Manchester and Helmholtz developed was found to be applicable to the living machine. The sun by its radiant energy converts carbon dioxide from the air and water into starch in the plant body. Starch after digestion and absorption into the animal body liberates that energy again into animal heat and mechanical (muscular) energy.

Other advances in physiology during the nineteenth century and after grew logically from these chemical conceptions of the nature of life.

How the blood does its work of carrying oxygen from the lungs to the tissues, exchanging a load of oxygen there for a load of carbon

dioxide, the waste product, which is then carried back to the lungs to be thrown off in the expired air, was suggested when Willy Kühne, a pupil of Claude Bernard's, and afterwards Professor of Physiology at Amsterdam, showed that the essential element of the red blood-cell was a crystalline chemical, which he named " hæmoglobin."

The complicated mechanism by which the red cell performs the simultaneous loading and unloading of the two gases in the lungs and tissues was revealed through the work of many investigators. Notable in this was Joseph Barcroft, a fascinating writer whose *Respiratory Function of the Blood* (1914) begins, strangely for a scientific treatise: " At one time, which seems too long ago now, most of my leisure was spent in boats," and goes on to describe his adventures in research as if he were sailing a cockle single-handed over the dark seas of ignorance. Others were John Scott Haldane and John G. Priestley, and our own Yandell Henderson, Professor of Applied Physiology at Yale.

Circulation, respiration, digestion, muscular action, nervous action, the chemical processes of nutrition, the blood — by 1890 all these were explained, at least in broad outline. Physiology is still working on the details. What was left?

One was the mode of action of the kidneys. For the elucidation of this, there was easily obtainable the excretion from the kidneys — the urine. Complete analyses of the urine in health and disease have been made and its composition under varying conditions determined: water, salt, nitrogen waste (represented by urea, uric acid, creatinine, ammonia), and, under diseased conditions, albumin and sugar are its main constituents. To an English eye surgeon, William Bowman, is due the theory of urinary secretion in the kidney, which still holds its ground. Bowman stated that the solid elements of the urine were secreted from the blood by the tubules of the kidneys, and the water by the Malpighian bodies of the kidney tubules.

The action of the peripheral nerves and their simple reflex action in the lower spinal centres had been explained by the work of Galvani, Bell, Magendie, Du Bois-Reymond, and Marshall Hall. There remained the mode of action of the higher nervous centres — the brain, the cerebellum, the pons medulla.

The idea that the brain was mapped out into a set of nerve centres, each presiding over a function of mind, was the idea of Gall and his pupil Spurzheim. In fact, they were right, but they had no idea of

scientific method, of the nature of proof, and they were too anxious to find a practical application for their theories. Hence, the founding of the false science of phrenology (1810), with atlases of the skull on which the qualities of the mind — benevolence, acquisitiveness, etc. — were confined to special areas, and the special development of any quality was indicated by a corresponding " bump " on the skull.

Phrenology is a good example of how a flash of inspiration in science can occur to totally unworthy people. There is no cosmic justice in it, but the fact remains that thorough technical education and preparation do not guarantee those divine sparks which alone make for scientific advance. As another example, the discovery of insulin was reserved not for all the deserving and hard-working specialists in diabetes, but for an orthopædic surgeon.

Phrenology fell into such disrepute that it really held back the investigation of cerebral localization, and when Flourens, " the father of brain physiology," published his experiments (1822–42), he was regarded in some quarters as no better than such quacks as Gall and Spurzheim. But he was far from that.

Flourens's first experiments were the classical observations on removal of the cerebrum and of the cerebellum in animals.

He removed the cerebellum in a young, healthy dog and noted the results. The animal lost the power of ordered and regular movement. When he tried to go forward, he would go back, and when he wished to turn to the right, he turned to the left. He made great efforts to move, but, being unable to control them, he would bound forward and suddenly fall over himself. If there were any obstacle in his way, he was quite unable to avoid it.

What was the explanation? That the cerebellum does not control voluntary motion or the intellectual faculties, but does preside over equilibrium and co-ordination of motion and sensation.

Flourens found a small spot in the medulla oblongata (which connects the spinal cord with the brain) which cannot be injured in the least without causing instant death. This he surmised was the spot which is reached by the needle of the garrotter in a Spanish execution or destroyed when a criminal is hanged. Flourens named this the *nœud vital,* the " vital spot." It is, though he did not suspect it, the respiratory centre.

Contemporary with Flourens in France, the brothers Weber (Ernst

Heinrich and Eduard Friedrich) in Germany showed that the heart was under the control of the nervous system. By placing one pole of an electromagnetic apparatus in the nostril of a frog, and the other on the spinal cord in the level of the fourth vertebra, they showed that the heart could be brought to a standstill. Narrowing the inhibitory field, they found that the centre is in the medulla, and the vagus nerve the path of conduction.

E. H. Weber made another set of discoveries, which he incorporated in the so-called "Weber's law."

The formulation of Weber's law was afterwards used by Fechner to bring the functions of the mind to the level of reactions in a retort. It founded experimental psychology. Weber showed that sensations induced states of mind not in proportion to the intensity of the stimulus, but dependent on the mode of application. We cannot see the stars in the day-time, though they shine just as brightly as at night. We do not hear the ticking of a watch in the busy street, but in the middle of a sleepless night its ticking, no louder than in the street, sounds like an anvil chorus. A definite stimulus to eye or ear is less perceptible when added to a larger than to a smaller stimulus.

Fechner reduced all this to mathematical formulæ and hurled at a shocked world his book on "Psycho-physics," which expressed love-affairs and poetic inspiration in terms of the stress of

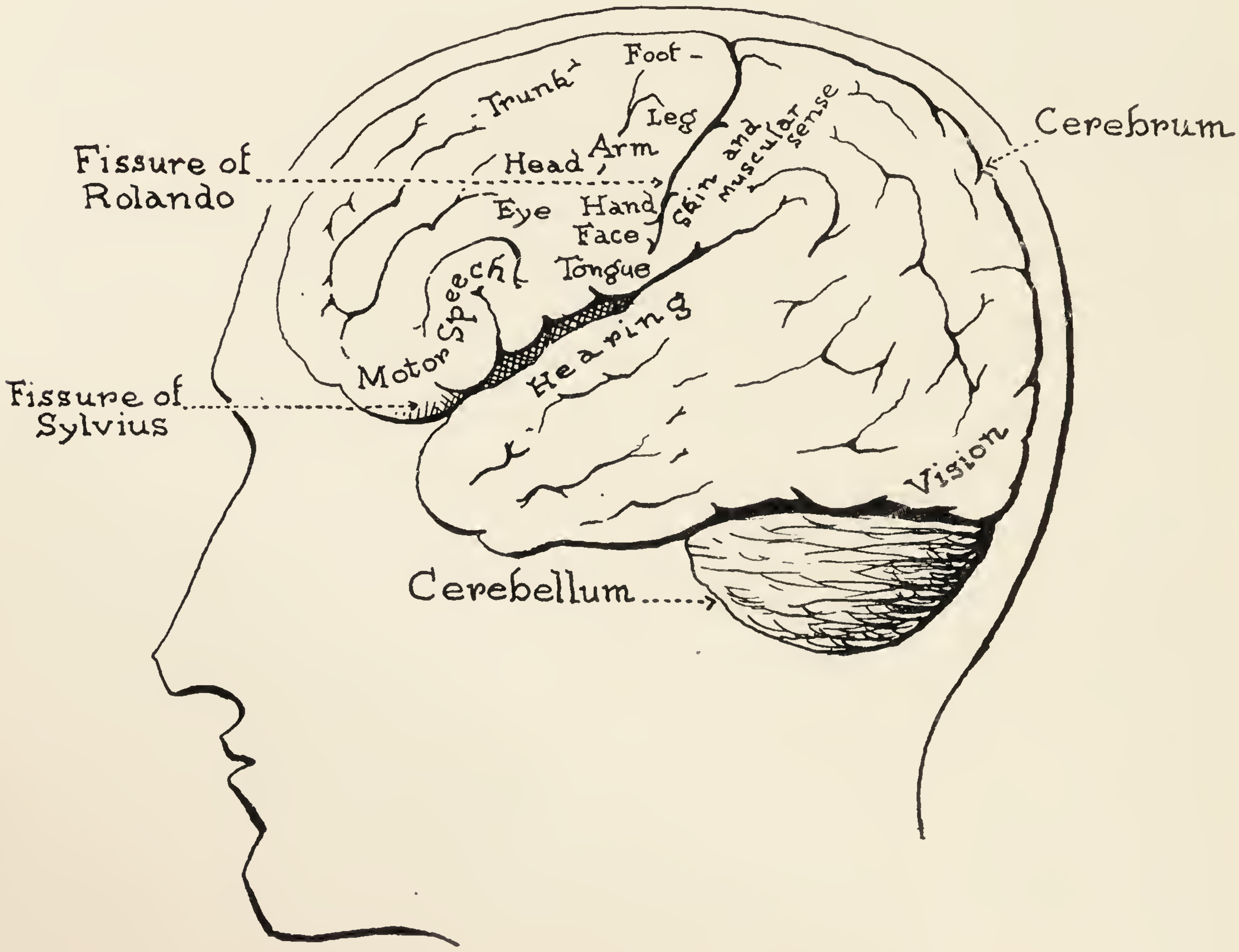
$$N \text{ on } D \div 3R_{n-D} = \frac{\sqrt{9621.}}{D \times R} - 2^n.$$

Obviously the grand-daddy of behaviourism and the father-in-law of Freud.

Fresh light was thrown on cerebral localization when, in 1861, Dr. Paul Broca performed an autopsy on the body of a patient. The patient had been under observation for twenty years at the Bicêtre. He was a complete man in every respect but one — he had lost the power of remembering words. He could make sounds with his organs of speech; so there was no muscular paralysis. He knew when he was hungry, he could play cards, add up a column of figures — so he could think. But when he started to answer a question he would say: "Now, I — there — o — " and the sentence would trail off into nothingness. The condition is called "aphasia." When the patient died, Broca found that the brain was intact except for a small part on the left side — the third

left frontal convolution. This had long ago been destroyed by disease and was only a shrivelled knob of scar tissue. Broca named it the "speech centre."

A new method of localization was introduced by Fritsch and Hitzig. They removed the bony covering of the brain in animals, and by application of an electric needle to the brain surface stimulated small areas of the brain and watched for results. They found, for instance, that the part of the brain where Gall had located Firmness, Conscien-



Localization of functions in the brain.

tiousness, Agreeableness, and Acquisitiveness, was, in reality, the far more prosaic set of centres for the voluntary control of the movements of the arm and leg.

With the establishment of aseptic surgery on a firm basis, it was possible for surgeons to explore the human brain in case of disease to confirm and add to the experimental findings. One of the pioneers in this field was Hughlings Jackson, who found that in epilepsy following brain injury, in which the convulsive muscular movements were confined to one arm and leg, the cortex of the brain on the opposite side

was diseased in the exact location corresponding to the motor area mapped out by Fritsch and Hitzig.

The extension of this work by Ferrier, Goltz, Cushing, Horsley, and many others has given us a practical working knowledge of the higher nervous centres.

PART VIII

MODERN MEDICINE AND SURGERY

Uniting all the past, applying the established facts of all the sciences — mathematics, physics, chemistry, and biology — adding to them all the practical methods of inventive genius, constantly supplying innovations and improvements, and itself suggesting ideas to the fundamental sciences, modern medicine faces the new world of the twentieth century calmly and confidently.

CHAPTER XXIV

ASEPTIC SURGERY

On August 12, 1865 the Professor of Surgery at the University of Glasgow was sitting in his little office in the infirmary. Crossing his legs and ruefully gazing down at his foot as he kicked it up and down, he thought to himself that surgery was at a low ebb. The name of the Professor of Surgery was Joseph Lister, and he was comparatively young for so important a position — only thirty-eight. He had held the chair, though, in Glasgow for five years, having come thence from Edinburgh. He had married the daughter of the great Dr. Syme, Professor of Surgery at Edinburgh, and everyone agreed that it was probably his father-in-law's pull that had got him his place. He himself would never amount to much as a surgeon — so they said.

For he had queer ideas about a lot of things.

He was not satisfied with the condition surgery was in, for one thing. He did not seem to think so much of the great men who were so proud to be called surgeons.

It worried him when a case of compounded fracture died in his wards. But everyone knew that over half of your compounded fractures died. What was the use of expecting anything better?

A compound fracture was what they called a break in the bone when the broken fragments of the bones cut themselves through the skin and protruded out of the wound. A simple fracture was one where the bones broke but the skin remained intact.

Young Mr. Lister knew quite well that if you splinted your simple fracture, the bones would knit, and in the course of time the patient would have as good an arm, or leg, or collar-bone, as ever — or, at least, nearly as good.

But your compounded fractures, they were the devil itself. The place

where the bones stuck out of the skin would begin to get red, then a lot of pus would form, and the stinking stuff would drain from the wound for ever. And the patient would get feverish and delirious, perhaps, and suffer tortures. Then, like as not, an erysipelas would set in, and abscesses higher up the leg or arm, as the case might be, would form, and finally in over half the cases the patient would die.

Nothing like this happened to the simple fractures. Those patients had no fever, and no abscesses, and no erysipelas. It was not because a *bone* was broken, then, so the Professor reasoned.

It had got to be an obsession with Joseph Lister. He knew well enough about the nature of the processes behind the pus and the redness and the swelling. These were indications of inflammation. He had given lectures on inflammation. He had written a book on it, published in 1857. But inflammation alone did not kill. Inflammation was a sort of healing. This gangrene in compound fractures was different.

Other things puzzled him. He had looked up his statistics on amputations. Forty-five per cent of his cases had died. Yet he did things in the most approved fashion — just as the great Syme, his father-in-law, did them. But those amputations acted just like his compound fractures. There was redness, swelling, inflammation, pus, fever, and, finally, death.

He had talked about the thing a good deal with other surgeons. They smiled indulgently. They said it was inevitable. The pus they called "laudable pus." It was necessary in the healing process. The first thing nature did in order to start healing was to form laudable pus.

But Lister was not so sure. He remembered a phrase of Hippocrates — something about healing "by first intention." That is, healing without the formation of pus. Why did some wounds heal by first intention and why did some have to form "laudable pus"? Why did not his compound fractures heal by first intention?

He talked about these things with everyone he met. A young medical student in Edinburgh, named Batty Tuke, saw a case with Lister in 1854. It was a popliteal case. Lister took off the dressing and found the wound healed except where the ligature had been applied.

He said: "The main object of my life is to find out how to procure this result in all wounds. But why is it not healed around the ligature?"

Boy-like, as he himself avers, Batty Tuke suggested: "The irritation of the silk."

Surgery in the most primitive form. An amputation as depicted in Gersdorff's Surgery, *1517. No anæsthesia. No attempt at asepsis, or even cleanliness. Hæmorrhage was controlled sometimes by a tourniquet during the operation, and cauterizing afterwards. Such operations could only be done as the direst necessity.*

"No," replied Lister, "not of, but *in* or *on*."

He often talked it over with his father-in-law, James Syme. Syme was a genial and approachable man. Progressive, too! He had adopted the new American method of using ether to put his patients to sleep when they were operated upon. He and Pirogoff, the Russian, were among the few European surgeons to do it fifteen years before, when Lister was a dresser at Edinburgh. But Syme was a man of few words, and a Scotchman at that — what he did not know, he did not know, and that was all there was to it. Joseph Lister got no help from him in this puzzle.

Then Professor Thomas Anderson, the chemist at Glasgow, gave him a hint — the first hint he had about his problem.

"See here, son," said Anderson to him, one day in that same year of 1865, "have you read any of these papers of this crazy Frenchman — a chap named Pasteur?"

Lister had not.

"Come over to my chamber and I'll give you a copy," said Anderson. "I think they're somewhat in your line."

Anderson knew Lister was interested in inflammation, and, for all anybody knew, inflammation might be a form of fermentation.

The papers by Pasteur were very queer — very queer indeed. The young professor was puzzled over many of them. This Pasteur was not a medical doctor at all; he was a chemist, like Professor Anderson. One of his papers had to do with changing one kind of tartaric acid into another kind. It was not easy for a professor of surgery to understand. But then there was an idea — some surgeons claimed that inflammation was due to a change in the nature of the fluids in the tissues. If chemical changes could occur in minerals, why not in human tissues? Well, there a person was.

Then another of these papers showed that wine fermented from something that dropped into the grape juice from the air.

The air — here was an idea. The young Professor of Surgery began to get excited. *The air.* That was the difference between the simple fracture and the compounded fracture. Air got into the compounded fracture. Now, if there was something in the air that caused these intensive inflammations and the laudable pus to form, it might explain things.

The professor began to think. What about his amputations — why did so many of them go wrong? Well, the air got to the exposed bone and flesh, too, didn't it?

He and Professor Anderson talked all night about these questions. Then he talked to his dressers about it. Many facts fitted into the theory.

For instance, there were some places in the body no surgeon dared penetrate. Even ten years later Sir John Erickson was to say that operative surgery had reached its finality, and that there were three regions into which the surgeon could never enter with impunity — the brain, the chest, and the abdomen.

Not only that, but joint surfaces. Larrey, the surgeon of the Napoleonic armies, did thousands of amputations at the hip. But only three ever lived.

Yet sometimes the thing was done. There was an account in Cheselden's Surgery of a wound in the abdomen and the patient didn't die.

Then there was Spencer Wells in London. He took out ovaries successfully — had been doing it since 1858. When you remove an ovary, you have to go into the abdomen. You have to enter the peritoneum.

And McDowell, the American! The young professor had heard about McDowell. McDowell had taken out an ovarian cyst in 1809 and had performed the same operation several times thereafter.

What was the secret? Why did some people have no trouble when they let the air into a wound, and others have trouble?

Perhaps the air was different at different times. Perhaps some air had a fermenting principle in it and some did not. The professor was strongly inclined to think that was it.

But what to do about it? That was quite as much of a puzzle as any other aspect of the case. You can't exclude air. It is everywhere. What to do?

Was it possible to change the air in some way and kill off the fermenting or inflammatory principle in it?

Professor Lister bothered everyone with his doubts and speculations.

At last, one day, a visiting surgeon from Carlisle said:

" See here, Lister, you know we have had an experience with the sewerage at Carlisle which I believe would interest you."

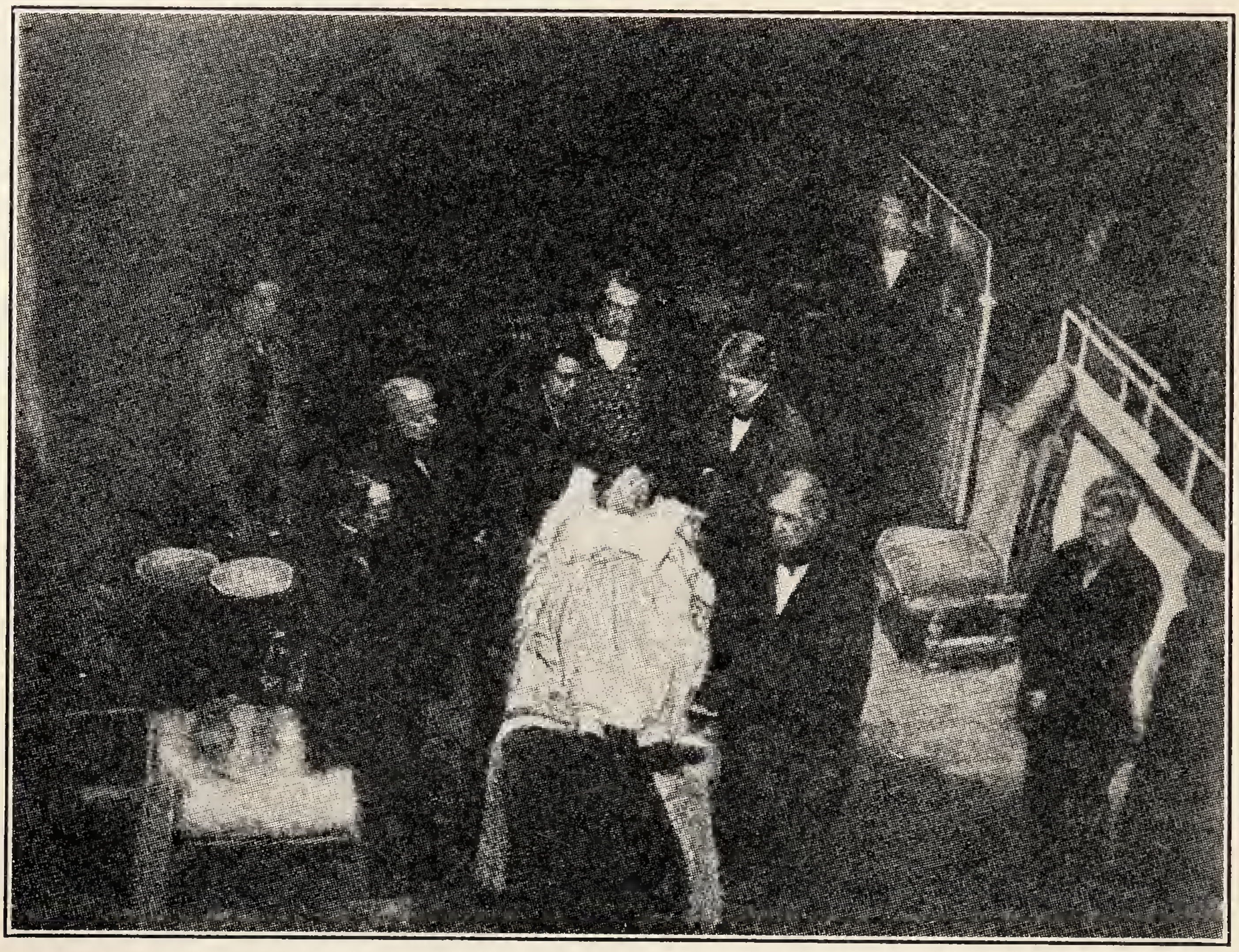
" What was that? " asked Lister.

" Well, since you think decomposition and gangrene and all these stinks that you have to keep the windows of your wards open to avoid, here in Glasgow, come from some fermenting substances or germs, or something of that kind, you want a way to kill them, don't you? "

"Yes, yes," said Lister, eagerly.

"Well, in Carlisle we had a very stinking sewerage system. There were privies that smelled to high heaven. But you know what we did? — we put carbolic acid in the sewers — and by Gad, sir, the smell has disappeared from Carlisle."

"Carbolic acid — phenol, eh?" Lister asked.



The evolution of surgery-anæsthesia. One of the first operations under ether. From a daguerreotype. Dr. John Warren stands far down in front at the left side of the table. W. T. G. Morton stands at the patient's head. The room is the ether room of the Massachusetts General Hospital in Boston, and an attempt has evidently been made to reconstruct the scene of the first administration of ether, publicly done, for a major surgical operation.

"Ay — phenol. Now, of course, I don't know whether the smell disappeared because the septic particles were killed or not, but I do know the sewers and privies did not smell of carbolic very strong."

"What did they smell of?"

"They didn't smell much of anything," replied his colleague. "And there was another thing," he continued; "we had a lot of trouble with a disease of cattle feeding on pastures which were irrigated with the sewage — one of your damned entozoan disorders of some sort or

other. By Gad! Do you know, sir, we've had none of that since we used the phenol?"

This conversation made a great impression on Lister. He decided to paint a compound fracture with carbolic acid.

He did so in March 1865.

Disappointment and confusion. The man died, in spite of the treatment — died just as all the others with compound fractures died.

But still he pondered the matter.

On August 12, 1865 his dresser, Hector Cameron, knocked on the door and came in.

"Theer's a compounded fracture of the tibia just been admitted tae the ward, chief," he announced.

"A compound fracture, eh?" responded Lister. "Well, get me some carbolic acid. I am going to paint it with that."

"I hope ye have better luck wi' it than ye did wi' the puir lad ye tried it on a bit back," said the assistant.

"I hope so, too, Hector," answered his chief, grimly.

So, with a ring of incredulous faces about him, he painted the edges of the wound and the protruding splinters of bone with the carbolic. Then he dressed the leg carefully.

"See here," he said, suddenly — "Sister, I want the cleanest towel you have in the house to dress that wound with. And mind that you put it in a pan and boil it first."

In those days hospital dressings were obtained by asking housewives to send bundles of their old linen. Nothing was done to them — they were not even washed before they were put on wounds.

We may be sure Dr. Lister watched his patient with the compound fracture very carefully. He changed the dressings next day and again swabbed the open surface with the carbolic.

He wrote his father, with whom he kept up a regular correspondence, as a dutiful son should. His father, Joseph Jackson Lister, was a very great man himself. He had, with Wollaston, perfected the compound microscope much as we now have it. He was a man of science — indeed, a Fellow of the Royal Society. So his son felt free to discuss with the greatest freedom matters of scientific interest with his father.

"There is one of my cases at the Infirmary which I am sure will interest thee," wrote this Quaker son to his Quaker father. "It is one of compound fracture of the leg: with a wound of considerable size and

accompanied by great bruising and a great effusion of blood. . . . Though hardly expecting success, I tried the application of carbolic acid to the wound to prevent decomposition of the blood, and so avoid the fearful mischief of suppuration throughout the limb. Well, it is now eight days since the accident, and the patient has been going on exactly as if there were no external wound, that is, as if the fracture were a simple one. His appetite, sleep, etc., are good and the limb daily diminishing in size, while there is no appearance whatever of any matter forming."

Finally the patient was discharged from the infirmary with a good leg and a record of recovery so uneventful as to be a marvel to the whole city.

In the meantime Lister had been trying the procedure on other cases. One was a boy whose arm had been mangled in a machine at a fair. "Without the assistance of the antiseptic treatment," as he told the Section on Surgery of the British Medical Association, two years later, "I should certainly have thought of nothing else but amputation at the shoulder joint."

"My dear Father," he writes under the date of June 11, 1866, "I have really little or nothing to write about this week." Nothing much to write about! Only one of the ten most important things that have ever happened to the human race! "I have a continued good report to give of the compound fracture, which is, indeed, now no longer a case of uncertainty."

Whatever else Joseph Lister may have been, you cannot get into the same atmosphere with him without a feeling of peace and love of truth.

He got several new ideas. Instead of washing his hands after a surgical operation, as most of his colleagues did, he washed them before. Instead of wearing a dirty old coat, with dried blood and pus on it, to operate in, he wore a clean linen apron. Instead of having his thread and needle stuck in his lapel, he invented a way to sterilize ligatures.

And the air which he thought was so important a source of infection — he had that sprayed with carbolic acid and water from a kind of donkey-engine.

His results were unbelievable. Indeed, they were unbelieved. "Hospital gangrene" almost disappeared from the Glasgow infirmary. "Hos-

pital gangrene" was the frightful infection which got into every open wound in the hospitals of that day. The windows of the ward had to be kept wide open, the stench of the gangrene was so terrible. It was even seriously debated whether or not to close and burn every hospital in England, the scandal of the matter was so great.

The surgeon's coat. A regular part of the furniture and equipment of the operating-room of pre-antiseptic days. Note the needles and thread in the lapel. The coat was dirty and blood-stained.

On March 16, 1867 he reported his results in an article in the *Lancet,* the great English weekly journal of the medical sciences. On August 9 of that year he read his paper "On the Antiseptic Principle of the Practice of Surgery" to the British Medical Association meeting at Dublin.

It was probably the most important address ever made before a group of surgeons.

And what did the surgeons do? Most of them laughed. Most of them winked. Some got angry. Lister was a little balmy. Or just a plain liar.

But others believed him. Some went to Glasgow to see his results and came away convinced. Donkey-engines spraying the air with carbolic acid were common things in operating-rooms then.

The air of surgery, indeed, from 1867 to 1885 was full of carbolic acid and controversy.

Here was young Lawson Tait, for instance. He had settled in Birmingham. He, like Lister, had been an Edinburgh man and had studied under Syme. He left Edinburgh with one conclusion determined in his mind — "that I would never deliberately open an abdomen."

He had seen it done and had seen that the results were too awful. "The results [of ovariotomy]," he wrote, "I have seen in Edinburgh were truly awful — some thirty cases and not a recovery."

Long afterwards he penned a sketch of the surgical conditions of those days:

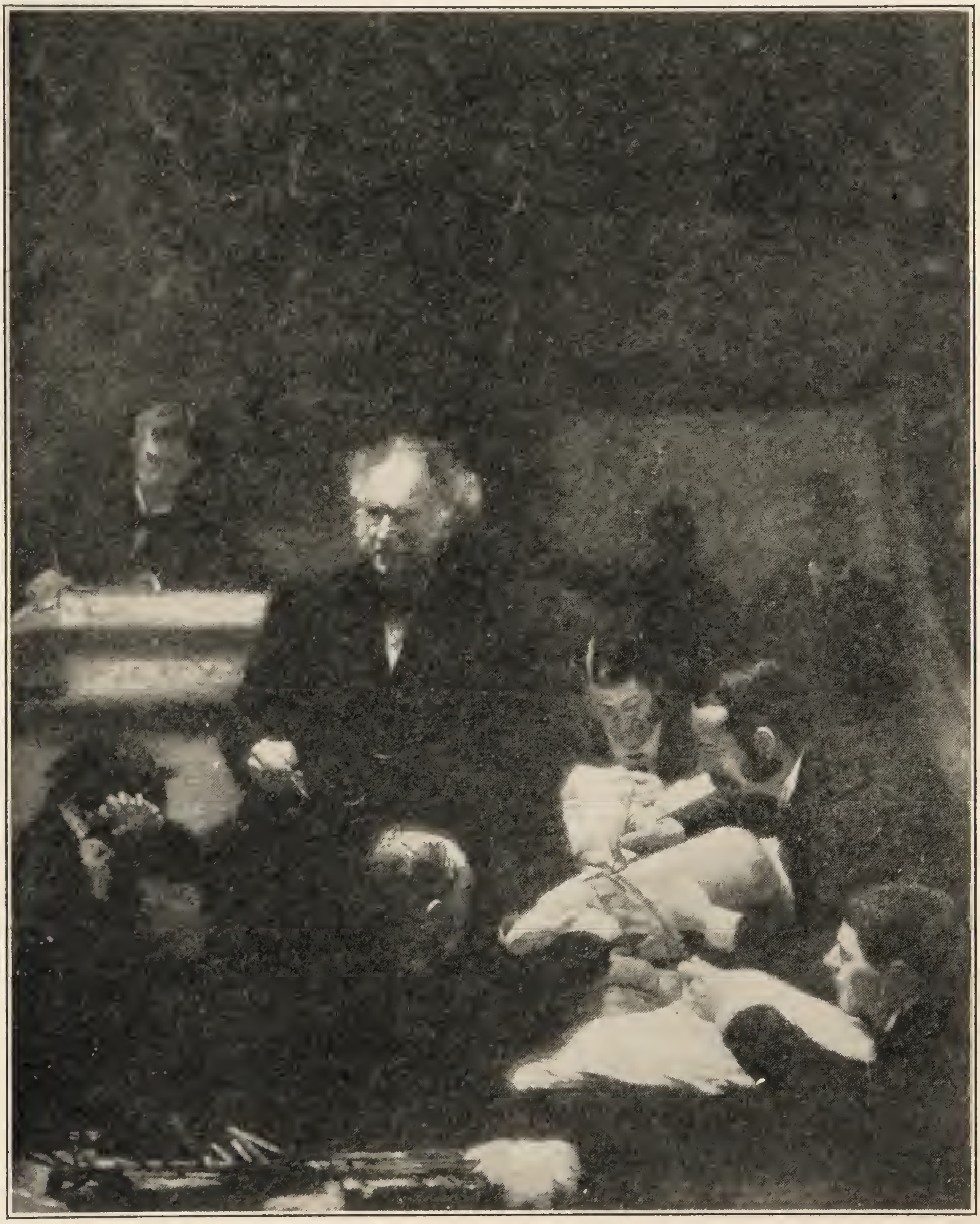
"Personally, Syme was the personification of the best type of gentleman, always perfectly dressed in his old fashioned way and clean as a new pin. From his boots to the top of his head, no one ever saw dirt, disorder or the appearance of hurry. He was always washing his hands — I think I may say he washed them every time he touched a patient.

"Through the folding doors what a difference. Everywhere hurry and untidiness, and no mark of what I praised in Syme. There was a good deal of dandiness, but much dirt. . . . The wards stank. The operating table was of wood and of fabulous age. . . . The only correct garb of the surgeon was a frock coat (the oldest and shabbiest in his wardrobe) which was kept in the surgeon's room and never renewed or cleaned during his twenty years of operating work. . . . The surgeons came direct from the dissecting room to operate. . . . Ligatures were used, which had been already soiled by handling with blood stained fingers, to bind up wounds in a second case. And at Edinburgh these ligatures were always worn ostentatiously by the House Surgeon, like a badge of knighthood, in the button hole of a coat, which often rivalled that of his chief for dirt."

No wonder Mr. Tait decided never deliberately to open an abdomen.

But he changed his mind. He was a good man with patients and he

got a large practice. There was an itch in him to cut. He knew of Spencer Wells in London. In 1858 Wells had opened an abdomen and



The evolution of surgery. Dr. Gross operating, about 1875. Note anæsthesia is used, but the operator wears a black frock-coat. From the painting by Eakins in Jefferson Medical College.

taken out an ovary, and the patient lived. He had done it frequently since.

In May 1868 Tait saw Mrs. "Aitch" in consultation. He found she

had a large floating tumour of the ovary, and, abandoning his former objections, he opened the abdomen and found that the tumour was cancerous and not removable. The patient died in seven weeks, but she had no peritonitis, which was the usual cause of death in ovariotomy. She died of her disease, not of the operation.

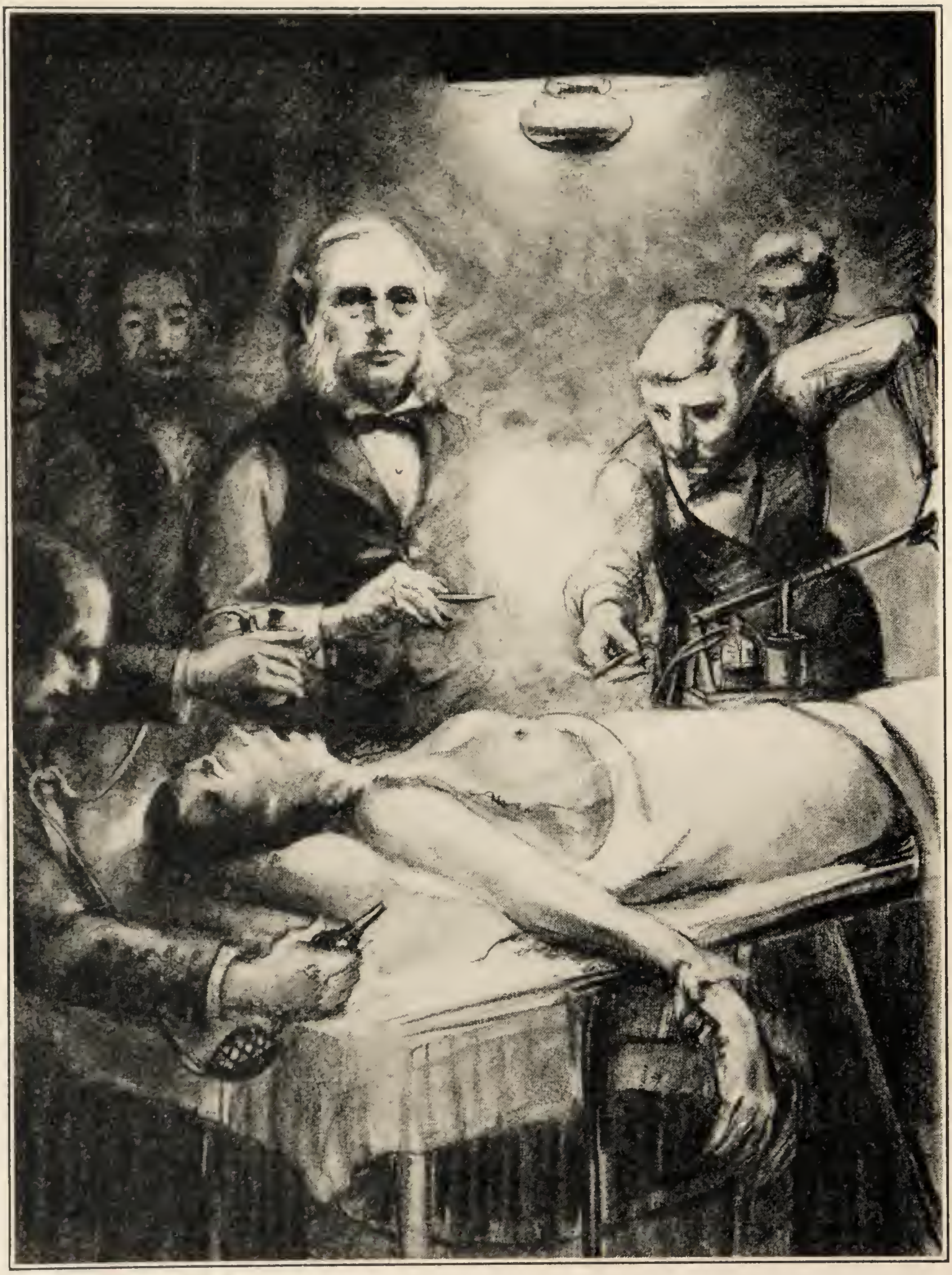
The fact that he could open an abdomen without causing peritonitis caused him to attack the antiseptic principle of Lister with great vigour, as he did in a paper called "Cases Treated Antiseptically on Lister's Method" in the *Lancet* for January 14, 1871. "My opinion of the antiseptic method is that its merits have been greatly overrated." Such good results as were reported he thought were due more to cleanliness than to the exclusion of air.

In October 1871 he saw in consultation a woman, aged forty-two, who had suffered for years from an agonizing pain in the pelvis in the region of the left ovary. "After careful thought," he wrote, "I ventured to suggest to my colleague the removal of the ovary would probably cure her. I recognized the gravity of the proposal for I had no fear that her suffering would kill her, but," he explained, he felt he could relieve the dreadful agony she constantly suffered. "The patient and her friends arrived at the same conclusions." And on February 11, 1872 he opened the abdomen and removed the ovary, which was "as large as a pigeon's egg and full of thick grumous matter," which he at first thought was a dermoid cyst, but which he afterwards concluded was a chronic abscess. "The patient made a speedy and complete recovery, and has remained since completely free from pain in the pelvis."

So the women came flocking to Birmingham, and Lawson Tait operated on them without using Lister's donkey-engine.

But he used cleanliness. He washed his hands thoroughly before an operation. So did all his nurses and assistants. He wore a sort of apron, or gown. All the sponges were soaked in muriatic acid and rinsed in hot water before use. The instruments were washed and soaked in hot water.

Gradually the atmosphere cleared. In 1878 Robert Koch showed the cause of wound infection to be the germs called staphylococci and streptococci. Lister gradually gave up his idea that the air contained the substances which caused hospital gangrene. It began to be the custom to boil the instruments and sponges to be used in an operation and thus kill the germs responsible for infection. Ligatures, to which Lister de-



The evolution of surgery. Joseph Lister operating, on the principle of antisepsis — killing the germs which infect wounds by spraying the air and skin, etc., with carbolic acid.

voted much time, were almost universally prepared, as he advocated, by soaking in carbolic acid. But the donkey-engine and the carbolic spray had disappeared almost completely by 1890.

The evolution of surgery. Spencer Wells operating. Anæsthesia is used, and the surgeon wears a clean gown, washes his hands and also the skin of the patient, and boils the instruments. But he does not protect his hair or beard or wear rubber gloves.

And in that period between 1867 and 1890 all surgery had undergone a change. Hospital gangrene, erysipelas, septicæmia, running wounds, stinking wards — all disappeared. In 1881 Billroth, the great Viennese surgeon, opened the way for operations on all organs by removing the

The evolution of surgery. A modern operating-amphitheatre. Anæsthesia: asepsis; instruments, gowns, rubber gloves, and ligatures sterilized. Hair and mouth of operators protected. Wound protected from patient's breathing, by enclosing the patient's head in a tent. During a modern operation the patient has almost disappeared.

stomach for cancer, and later by doing operations on the intestines. Operations for removal of the womb, of the appendix, of gall-stones, etc., soon followed. If one were to attempt to decide who did which of these first, one would get into enough trouble to satisfy any stickler for historical accuracy.

And in the meantime, too, all the rancour died away and Joseph Lister lived in the sunset period of his life in a sort of halo of glory shed over him by the whole world of surgery and medicine and, indeed, science.

On December 27, 1892 the Republic of France, in the person of its President and Deputies, met at the Sorbonne to do honour to Louis Pasteur on his seventieth birthday. The old gentleman was weak and ill and broken. He entered the hall leaning on the arm of President Carnot, and as he did so, Lister, who was present as the representative of the Royal Society of London and the Royal Society of Edinburgh, in a gesture of infinite grace and majesty, rose and with outstretched arms came forward, his eyes brimming with tears of devotion and respect, and embraced his comrade. For a moment these two among the greatest of the sons of men stood together, a symbol of the common brotherhood of science.

CHAPTER XXV

THE RISE OF SPECIALISM

The vice of the medical historian, one that is almost inherent in his material, is that his narrative gives the impression that progress in the healing art was due to a steady and logical development of discoveries made by initiated and approved practitioners and professors. But this view is incomplete.

A truer picture of medical progress would consider the balance of two forces. On the one hand we have the formal academic organization of the profession, with its schools, its own doctrine, and its own methods of practice. On the other hand there has always been a large group of practical people, uneducated in medicine, who developed methods of treatment without any reference to the theories of the schools. These two elements acted and reacted on each other in varying degrees. In olden times the irregular "healers" contributed quite as much to academic theory as the academic practitioners themselves.

Out of the irregulars grew the specialties. Until recent times when the licensing of practice became a function of government, the irregular healers, charlatans, and quacks travelled over the country-side, setting up shop in the town square and attracting a crowd of patients. Practically all dentistry was practised in this way.

Travelling stone-surgeons, who pretended to remove stones from the heads of lunatics and idiots, are frequently pictured by genre artists. One of the first eye specialists was Sir John Taylor (1708–67), who travelled over Europe in a coach which was decorated with painted eyes. Herniotomists and lithotomists confined their work to their own specialty.

All surgery was in the hands of practitioners with little formal education — barber-surgeons or wound surgeons. It was beneath the dignity

of the physician of the long robe to stoop to the menial task of cutting the flesh or manipulating a fracture or other injury.

In the course of time these irregular practitioners accumulated so

The beginnings of specialism. A strolling dentist. Note the barber's bowl with the crescent-shaped indentation in the rim to fit into the customer's neck. (From the painting by Gerard Dou in the Dresden Gallery)

varied and valuable a body of practical knowledge that it was necessary to take it into regular academic practice.

The first dental school was founded by Chapin A. Harris in Baltimore, in 1840. The first chairs on diseases of the eye were established

in 1873. Previous to that time the plight of a patient with eye disease was pitiful indeed.

As an example, a story is told by a pioneer American oculist of a patient who came to him with a cinder in his eye; it had been there so long that it had produced ulceration. The oculist, on being told that the patient had made three visits to another doctor, asked what had been done. "He told me to take three rounds of calomel," was the reply.

A detailed study of the history of the specialties would be of little interest to the lay reader. But some knowledge of their birth struggles is necessary for an understanding of modern medicine.

1. *The Eye*

Eye diseases were among the most frequent for which sufferers sought the healing powers of the gods in the Greek temples. We deduce this from the votive tablets left in the temples. The patients, according to custom, had the part of the body which was diseased sculptured in these tablets. The eye tablets are conspicuous by their numbers.

In the Orient two eye diseases, ophthalmia and cataract, have always been tremendously prevalent. Ophthalmia is an infection of the lids and conjunctiva — most often the disease called "trachoma."

In the earliest printed treatise on the eye — the *De Oculis* of Benevenutus Crassus of Jerusalem, 1474 — we find these two diseases occupying most of the book. The order of its contents gives a good idea of the importance ascribed to the different branches — first the structure of the eye is briefly considered; then cataract, for the relief of which an operation is described; then the opacities of the eye, which read like tuberculosis and other corneal infections; then the treatment of ingrowing lashes, and, lastly, itching inflammation and "humours" of the eyeball. The author was probably an itinerant "specialist."

After the introduction of printing, spectacles became one of those necessities which are the mothers of inventions. To the majority of the population, who could not read, the growing difficulty of visual accommodation which comes with age would have been unnoticed before that. To the learned, the clerical manuscripts were in sufficiently large characters to occasion no great inconvenience. But with printing the number of readers increased, and so about the middle of the fifteenth century we find spectacles beginning to appear in paintings. The Chi-

The beginnings of specialism. Travelling stone-surgeon at work. These charlatans would set up shop in the market-place and pretend to remove stones from the heads of the village idiot or madman, claiming that the stones caused the madness. The " doctor " palmed the stones and, after making an incision in the scalp, let them rattle from the wound into a basin. They also performed the operation for epilepsy and headache.

nese are popularly credited with the invention of spectacles. Popular legend to the contrary, according to Dr. Shastid, they were not introduced into Europe from China. Roger Bacon's suggestion that old people, weak of sight, might be given assistance by means of a convex lens antedated the earliest citations to Chinese writings. In Europe the tomb of Armati of Florence, who died in 1317, ascribes the invention of spectacles to him. But this is doubtful. Dr. Shastid states that the first inventor of spectacles is unknown, and the *re*-inventor was Alexander

Early picture of spectacles. The saint on the left is Saint Roch, the patron saint to guard against the plague. (St. Jacobskirche, Rothenberg)

de Spina, who died in 1313. The first scientific treatise on spectacles was that of the Spaniard, Doca de Valdez, published in 1623.

Improvement in spectacle-making, however, was slow. Pepys ends his diary in 1669 with a pious hope that God will prepare him for all the discomforts that will accompany his going blind. Yet he lived thirty-odd years afterwards and his vision remained good until the end. As a modern oculist says, all his agonies of anticipation could have been relieved by a lens of two diopters. — Benjamin Franklin, in 1748, invented bifocal lenses.

The real obstacle to progress in spectacle-making was lack of knowledge of the accommodation of the eyes. Not until the versatile Thomas Young, in 1793, presented his theses was this overcome. He studied his

own eyes in front of a mirror with compasses. He knew, as part of the science of optics, that if a distant object be brought into focus, one of two things must happen to the eyeball. Either it must lengthen its total depth, or the lens must change in thickness. With the callipers he proved that the eyeball itself did not change in depth. Young concluded that accommodation to distance is due to changes in the convexity of the crystalline lens of the eye, and, second, that changes in the lens are accomplished by the musculature of the lens. He was wrong in the details of the latter part of his doctrine: the lens is not muscular, but its contour is changed by muscles, so for all practical purposes Young's ideas were correct.

We have all seen, when automobiling at night, the flare made by the lamps on the car illuminating the eyes of a prowling animal in the road ahead. Our ancestors had no such powerful lights, but still they must have noticed the same phenomenon. It induced them to want to see into the back of the living eye. Why is the pupil so dark when you look straight at it? How can that darkness be penetrated?

Jean Méry of Paris in 1704 accidentally (I don't know how, but that is what my record states) held a cat under water and observed that the pupil dilated as a result of suspended animation, and that then the unparalleled glory of the fundus was revealed — the optic nerve, the delicate blood-vessels, the lovely colouring of the dome. This was due to the action of the water in obviating the refraction of light.

Various attempts were made to see inside the human eye. Brücke, one of the four young men who, with Helmholtz, projected the new physiology, in 1847 passed a tube through the flame of a candle and, looking through the tube at an eye, could see the red reflex. The flame furnished the illumination, and the tube shut out the refractive light-rays. He did not report his experiment, but, as Dr. Shastid says, he almost invented the ophthalmoscope.

The unfortunate who really did invent it was Charles Babbage, also in 1847. He used a bit of plain mirror with the silvering scraped off a small place in the back. Through this he could look at the eye as the mirror reflected light into it. Babbage sought out the greatest ophthalmic authority of the day, Thomas Wharton Jones, but Jones said it was worthless.

The credit for the invention of the ophthalmoscope and for thus founding the science of ophthalmology goes to Hermann von Helm-

holtz, in 1851. "I was endeavouring," he wrote, "to explain to my pupils the emission of reflected light from the eye, a discovery made by Brücke, who would have invented the ophthalmoscope had he only asked himself how an optical image is formed by the light returning from the eye. In his research it was not necessary to ask it, but had he asked it, he was just the man to answer it as quickly as I did, and to invent the instrument. I turned the problem over and over to ascertain the simplest way in which to demonstrate the phenomenon to my students. It was also a reminiscence of my days of medical study, that ophthalmologists

The ophthalmoscope, in the form invented by Helmholtz. The examiner reflects a beam of light through the patient's dilated pupil, focusing the beam on the back of the eye by means of the lens held in his left hand. (*From* Das Leben des Menchen, *by Fritz Kahn. Stuttgart Gesellschaft der Naturfreunde*)

had great difficulty in dealing with certain cases of eye disease, then known as black cataract. The first model was constructed of pasteboard, eye lenses, and cover-glasses used in the microscopic work. It was at first so difficult to use that I doubt if I should have persevered unless I had felt that it must succeed; but in eight days I had the great joy of being the first who saw before him a living human retina."

The news of this invention affected two young men like a bugle-call in the night. In Berlin, Albrecht von Gräfe had just returned from study in the medical centres of Europe. In London he had been fortunate enough to meet two men who, together, knew more about the anatomy

and physiology of the eye than all the rest of the world put together. They were Donders and Bowman, and to their scientific knowledge von Gräfe added the finest store of clinical knowledge of the eye in existence. For a year they were inseparable, studying at Moorfield's Hospital in London, then, as now, the mecca for students of eye disease.

On hearing of the ophthalmoscope, von Gräfe wrote to von Helmholtz requesting that two instruments be sent him. His fellow-student Donders, who had set up practice in Utrecht, did the same, but, impatient of any delay, constructed an improved instrument from von Helmholtz's description.

Von Gräfe established the first clinic for eye diseases in Berlin. In the next ten years he had introduced the operation of iridectomy for iritis and glaucoma, the operation for cross-eye, and an improved operation for cataract, had studied and recorded the appearance of the eye grounds with the ophthalmoscope in nearly all diseases, and had made a host of other observations too technical to describe in detail. His clinic became famous all over the world. His pupils went out to found eye clinics all over the world.

Donders's work was more technical, but it laid the foundation for the adjustment of glasses to astigmatism and all other errors of refraction.

Von Gräfe's useful life was cut short by tuberculosis. In 1861 he had his first attack of pleurisy. Although conscious of the seriousness of his condition, he worked on; hæmorrhages from the lungs and cough incapacitated him, but he worked every day in his clinic, frequently supported by opium, until at the age of forty-two he died during the night of the 20th of July 1870.

Only one modern name is worthy to stand with those of von Gräfe and Donders, that of the Swedish oculist Allvar Gullstrand. Of his many important contributions, the most astonishing is that of the slit lamp for the study of the interior of the living eye. It allows the oculist to observe the interior of the eye as if it were under a microscope, each cell appearing in such proportions.

Ophthalmology today is the queen of the specialties — the most completely scientific and most completely competent branch of medical practice.

2. *What Medicine Learned from a Postmaster*

Guyot, the postmaster at Versailles, was troubled in body, mind, and spirit in the year 1724. He was troubled in body because he noticed that he was gradually becoming deaf. He was troubled in mind because he kept hearing noises — cracklings and snappings and musical notes and voices and whistles — even when he was shut in a quiet room. And he was troubled in spirit because he did not want to become deaf and because he was afraid the voices in his head meant he was going crazy, but mostly because nobody could suggest anything for him to do.

Not a doctor himself, he went the rounds of the best medical men he could find. They could do nothing for him. One said that his trouble was due to wax in his ears and tried to scrape some out. There was little wax in Guyot's ears, but he washed them out and douched them with warm water for many a day after this consultation. With no benefit. His deafness increased; his head noises were still present.

"Nobody knows anything about the ear," one doctor told him. "All who treat deaf people are quacks."

"Deafness is incurable," said another. "It is an affliction sent by God. If you are deaf, you were intended by God to be deaf. To interfere with His purposes is impious."

But Guyot did not believe these statements. He saw no reason why it was any more impious to attempt to relieve deafness than it was to attempt to relieve any other affliction. Here was everybody a few years ago having his rectum cut because the King (Louis XIV) had been cured of a fistula *in ano*. They were no more pious than he, Guyot. There was no more reason why God should inflict punishment on Guyot than on these pocked courtiers.

True enough, there were no doctors who treated ears or knew anything about ears. He had found that out. But there was no reason why something should not be found out about it.

"Get a boy to beat a drum in your house, Guyot," laughed one doctor, and pointed out to him a passage in the famous works of the famous Dr. Willis.

"Indeed," wrote that worthy, "a certain kind of deafness occurs, in which, although the patients seem completely to lack the sense of hearing, yet so long as a great din, such as that of bombardments, or of

chimes, or of bells, or of drums, resounds about their ears, they take in distinctly the conversation of those about them, and answer questions intelligently, but, upon the ceasing of such tremendous uproar, they immediately become deaf again. I once had it from a trustworthy man that he had been acquainted with a woman, who, although she was deaf would nevertheless hear distinctly whatever was said so long as a drum was beaten within the room, and consequently her husband employed a drummer as a household servant, in order that by his aid he might occasionally hold conversations with his wife. I have been told of another deaf person, living near a bell tower, who could easily hear any voice whenever the bells were pealing — but not otherwise."

Guyot read these words and knew in a way they were true. They corresponded to his own experience. But *hein!* A man in his position could not hire a drummer. And he lived near no bell tower. Besides, he heard queer noises enough in his own head.

But there must be some other information in books about the ear, he thought. He asked his medical consultants. But he found little or nothing. Then he began to wonder how the ear was built. And here he met with more success. He could and did find books in which the anatomy of the ear was described. Among others, the recently published book on anatomy of the long dead contemporary of Vesalius, Eustachius. And here he found a clear description of that hollow tube or canal which runs from the throat to the middle ear, called the Eustachian tube.

This began to interest him. Because, like all people who have a chronic disease, he observed things about himself and had formed some theories as to the cause of his symptoms. One of the things he had observed was a feeling of fullness in his ears — as if a person were shut up in an air-tight room.

Now, with some idea of the construction of the ear, he formed a theory to account for this sensation. The Eustachian tube normally carried air from the throat into the middle ear, and the presence of this air was necessary for perfect hearing. But if the end of the Eustachian tube was stopped up, then the air could not get in — and this was exactly the way his own ear felt.

Then he knew that the Eustachian tube opened into the throat just at the back of the nose. And Guyot had a good deal of nasal discharge and chronic stopping up. So he began to reason that perhaps this ma-

terial got over the opening of the Eustachian tube in his throat and produced his deafness and the head noises, and all his sensations, generally.

What to do about it? His inventive genius, driven by his own necessity and his sufferings, began to brood over the possibility of opening up this Eustachian tube. He devised a tin tube, curved about so that he could put it into his mouth and make it reach to the opening of the Eustachian tube in his throat. Then he fitted a leather cap over one end so that the tin would not cut or scrape the inside of his throat.

Finally he connected this tube to the reservoir of two small pumps, which were moved by two cranks, and a wheel. By this means he could force fluid through his tin tube.

Then he was able to try his experiment. He inserted, himself, the tube into his mouth and managed to clamp the leather extremity over the end of the Eustachian tube. He was aided in this by his own feelings. When it was in place, he started his cranks. He distinctly felt a variation of pressure in the ear on that side. You yourself can produce something of this sensation if you close your mouth, pinch your nostrils together, and force air through your throat: a fullness comes into the middle ear because you have forced air up the Eustachian tubes.

Guyot continued to wash the ends of his tubes for some time. Greatly to his delight, his hearing improved, the noises which had kept sounding inside his head got better.

He acquired a local fame. His neighbours and finally the near-by physicians came to inspect his apparatus. He tried it on other deaf people. The profession in Paris heard of it, and finally the postmaster of Versailles was invited to read a description of his method and exhibit his apparatus before the Academy of Sciences. The method he introduced is still used, in somewhat different form than his, in the treatment of similar affections.

Special attention to diseases of the ear had to wait a long time in the general course of medical history. Some isolated observations were made, but there was little attempt to give sufferers from these conditions systematic or sympathetic consideration until the middle of the nineteenth century. The first book to treat exclusively of the diseases of the ear was written in 1821 by Jean Itard, a French physician. It was not until the work of Sir William Wilde, in 1853, that the public in general began to recognize the diseases of the ear as a special field of

work. Dr. St. John Roosa of New York called Dr. Wilde the "Father of Modern Otology."

The principal procedures and methods of the ear specialist were gradually accumulated by various hands. We have seen that a postmaster showed the way to the manipulation of the Eustachian tube. A Benedictine monk, Pedro Ponce de León (1520–84), appears to have been the pioneer to be interested in the instruction of deaf mutes. His methods were recorded by Juan Bonet in a book published in 1620.

The use of the sign alphabet originated with an Italian, Giovanni Bonifacio, in 1616.

John Wallis was the first Englishman to teach a deaf mute to speak. The patient had lost his hearing at the age of eight; under Wallis's training he was able to read the Bible aloud so that it was understood and to carry on simple conversations by lip-reading. Wallis, who was Professor of Mathematics at Oxford, published a treatise on the subject in 1652.

Incision of the ear-drum, deliberately undertaken for the purpose of treatment, appears to have been first performed by Sir Astley Paston Cooper. Sir Astley, whom we have met before in consultation with Dr. Richard Bright and in leaving instructions for his own postmortem, was a general surgeon. But that did not prevent him from being interested in the ear.

One of the questions which attracted him was whether a person could hear with the ear-drum perforated. In the early part of the eighteenth century T. Cheselden, then surgeon to St. Thomas's Hospital, reported the case of a man who could hear perfectly although he could "smoke a whole pipe full of tobacco out through his ears which must go from the mouth through the Eustachian tube, through the tympanum." Cheselden did not, however, proceed to use this information for purposes of treatment.

Sir Astley Cooper knew of Cheselden's account and he was also much impressed with Sir Everard Home's account of the anatomy of the ear-drum. In 1797 a medical student presented himself to Sir Astley who had had suppuration in both ears for some time, and even the small bones of the middle ear were destroyed and removed. Yet, at the time he consulted Sir Astley, he heard very well. Sir Astley was able to demonstrate, however, that his ear-drums were still perforated. He had the student fill his mouth with air and close his nostrils. Then he held

a lighted candle to each ear, and as the student compressed the air in his mouth, it issued from his ears, this being demonstrated because "the flame was agitated."

Following this experience, Sir Astley perforated the drumhead, surgically, for the relief of deafness accompanied by clasme of the Eustachian tube. While these cases were moderately successful, they were not the ideal ones for the application of the operation. The credit for the advocacy of perforation of the drumhead in acute infection and pus in the middle ear belongs to an American, John Cunningham Saunders, who published a work in 1827. "Let it be admitted," he wrote, "that the tympanum has suppurated, ought the membrana tympani to be abandoned to a casual ulceration or is it better to open it by art? I am inclined to prefer the latter."

In 1841 a Dr. Hoffmann of Westphalia used a shaving-mirror with a perforation in the centre to throw a beam of light into the ear so that the drum could be observed. This idea was afterwards perfected by von Troltsch, who made the head-mirrors much as we have them now. Von Troltsch, however, was unaware of Hoffmann's previous use of his shaving-mirror. The speculum which is used to assist in the examination of the ear was first used by Gruber of Vienna and introduced generally to the profession by Sir William Wilde.

Operations on the mastoid, now so frequent, have had a curious history. It is well known that when pus accumulates in the middle ear, it may travel back to the mastoid cells. An unfortunate early attempt to open these cells by operation was performed, at his own request, on a Danish surgeon, named Berger. He was old and deaf and his case was not suitable for such treatment at all. He died of meningitis eleven days after the operation. The case appears to have acquired considerable fame and to have frightened surgeons off the operation for forty years or more.

Sir William Wilde opened the collections of pus which form outside the bone under the periosteum, but apparently did not go into the bone itself. Troltsch thought about it a long time before, in 1861, he opened a mastoid "with uncommon care, even with dread."

In 1864 A. B. Crosby, in the mountains of New Hampshire, in all likelihood never having heard of Troltsch's work, opened the mastoid in three cases with a carpenter's gimlet. No finer example of the courage, resourcefulness, and intelligence of the general practitioner can

be found. How valuable such a man was — still would be, if medical schools would turn him out!

The operation as now performed was perfected by Hermann Schwartze, whose first paper was published in 1864.

The advances in ear diseases since this time have been made possible by the advances in the general methods of medicine and surgery, by anæsthesia, by septic surgery, by bacteriology, anatomy, and physiology. Prominent names are those of Politzer, who improved the specialty all along the line; Ménière, who described the affections of the apparatus of equilibrium; and Barany, who provided practical tests for the equilibrium apparatus, now used to test out all air pilots.

3. *What Medicine Learned from a Singing Master*

Professor Manuel Garcia, a Spaniard living in Paris, was walking in the Palais Royal. It was September 1852. Garcia was a professor of singing, and a very scientific one. His father had been a singing teacher before him and handed down the traditions of a rigid system to his son and successor. Garcia taught the use of the voice as a science and insisted on a thorough knowledge of the anatomy and physiology of the larynx on the part of his pupils before they undertook any practical exercises.

He had written a scientific treatise on voice culture: *École de Garcia, traité complet du chant* (Paris, 1841). His whole life was wrapped up in his labour.

But one thing obsessed him. How he would like to see the living human vocal cords in action! He had pondered and puzzled over it.

On this beautiful September Paris day he was, he says, "preoccupied with the ever recurring wish, so often repressed as unreasonable, when suddenly I saw the two mirrors of the laryngoscope in their respective positions as if actually present before my eyes. I went straight to the surgical instrument maker and asked if he had a small mirror with a long handle and was informed that he had a dentist's mirror which had been one of the failures of the London Exhibition of 1851. Having obtained also a hand mirror, I returned home, impatient to begin my experiments. I placed against the uvula the little mirror, which I had heated in warm water and carefully dried. And then flashing on its surface with the hand mirror a ray of sunshine, I saw at once, to my

great joy, the glottis wide open and so fully exposed that I could perceive a portion of the trachea. When my excitement had somewhat abated, I began to examine what was passing before my eyes. The way in which the glottis silently opened and shut and moved in the act of phonation filled me with wonder."

The laryngoscope. A singing master visioned it in the clouds. (From Das Leben des Menchen, *by Fritz Kahn. Stuttgart Gesellschaft der Naturfreunde)*

This discovery, which seems so simple to us now, had very widespread consequences. Even if it resulted in nothing more than looking into the throat with an ordinary mirror in cases of sore throat — that is, without attempting to visualize the larynx — it did a great deal. That such an examination was generally neglected until quite recent times is difficult to grasp, but is nevertheless true. George Washington's fatal

illness in 1799 is not so long ago, as we measure human history. The outstanding complaint the dying father of our country made was of pain in the throat, swelling and constriction, difficulty of swallowing, and obstruction in getting his breath. Applications were put to the outside of his throat, but none of his attending physicians looked inside his open mouth.

Of course, Fothergill and Huxham, who in 1748 and 1757 described "ulcerous sore throat" (probably diphtheria), record the appearance of the back of the throat in this condition and undoubtedly were in the habit of examining the oral cavity, but I am by no means convinced that the habit was general among practitioners.

Even as late as 1887 the use of the laryngeal mirror does not seem to have been widespread. At least, so I gather from Sir Morrell Mackenzie's account of his consultation in that year on the illness of the Crown Prince Friedrich of Germany. The case was the cause of a very acrimonious controversy in which the Berlin profession went so far as to accuse the English physician of deliberately mutilating his royal patient. Mackenzie wrote as his defence an account of the case *in extenso,* under the title of *Frederick the Noble,* a copy of which I have before me. It is notable that when this English specialist in laryngology, who was called by the English Crown Princess (mother of the ex-Kaiser and daughter of Queen Victoria), arrived at Potsdam, he was surprised to find that not one of the consultants called to meet him was able to use the laryngoscope with any skill. It is impossible to suppose that had there been in Berlin a man of outstanding skill in diseases of the larynx, he would not have been summoned to consult in the illness of the future Emperor of the German State.

The formation of the first Laryngological Society in America was accomplished in 1873 in New York, and that date may be regarded as the beginning of the specialty of the nose and throat.

Among the great medical benefactions which have originated in the United States, none except surgical anæsthesia is second to the contribution made to diseases of the nose and throat by Joseph O'Dwyer, who was born in 1841 in Cleveland, Ohio. In 1872 he was appointed physician to the Foundling Asylum of New York City. Here he found his life problem in the sufferings of little children with diphtheria.

The horrors of an epidemic of diphtheria in the days before antitoxin are beyond our imagination. The death-rate was forty per cent, even

in mild epidemics. It was bad enough to see the little people sink minute by minute under the overpowering poison of the disease, until their eyes, so bright a few hours before, became glazed and lustreless, and that fatal purple began to tinge lips and cheeks. But this was as nothing compared to the horror of seeing those in whom the membrane had covered the glottis, and death became a slow suffocation, an agonizing and losing struggle to get air into the lungs, past the obstruction of the inflammatory swelling.

For such an emergency Trousseau, the great French physician, had introduced the operation of tracheotomy — making an opening in the windpipe at the base of the neck so that air could be breathed into the lungs below the obstruction. But it was not always successful. In fact, O'Dwyer, when asked afterwards what urged him most in devising his method of intubation, replied that it was the complete failure of tracheotomy at the New York Foundling Hospital from 1873 to 1880.

The chief cause of the failure of tracheotomy was that it was an operation of last resort — postponed until the patient was in the last agonies. O'Dwyer tried to find a method which could be used to open the larynx when the first signs of suffocation were evident. He attempted to open the larynx with a wire spring and then a small bivalve speculum. Both failed. At last he appeared one morning in the operating-room with a tube with a collar fitted on one end to prevent the tube from slipping down the throat.

On one of the first cases in which he tried it, he learned another lesson. He inserted it into the larynx of a little girl four years old, who became so terrified at the procedure that she clamped her teeth down on Dr. O'Dwyer's finger, and it required some whiffs of chloroform to induce her to relax. O'Dwyer then devised a curbed intubator and a small mouth-gag, and his apparatus was complete. In spite of the vast improvement in the management of diphtheria consequent upon the use of antitoxin, circumstances still arise where the procedure of intubation is necessary.

The credit of devising the first tonsillitome for cutting out tonsils also goes to an American, Phillip Syng Physick, who introduced it in 1828.

CHAPTER XXVI

THE X-RAY

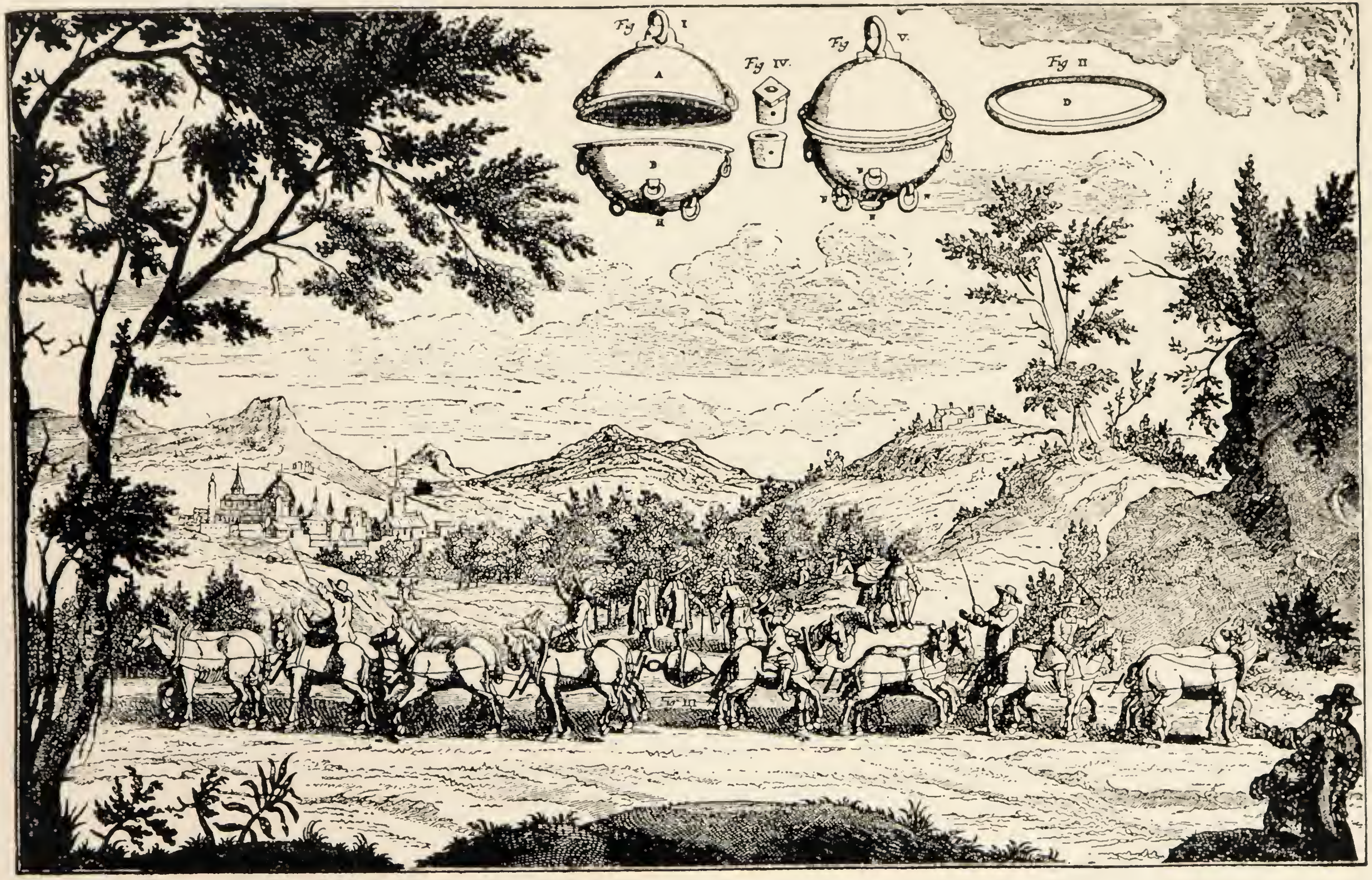
Strictly speaking, it began on that day in 1650 when Burgomaster Otto von Guericke invited the Emperor and his court to Magdeburg to witness his demonstration that air was stronger than horses.

Perhaps, even more strictly speaking, it goes back to 1643 when Galileo's pupil Toricelli invented the mercury barometer. Galileo had shown that water will rise in an exhausted tube to a height of thirty-three feet, but he was never able to offer an explanation of it. Toricelli thought that it was the pressure of the air, not the suction of some mysterious substance within the tube. The amount of water held in column, he reasoned, was simply the equal in weight of the outside air. And, he continued, if that were so, a heavier liquid would be held up to a height proportional to its weight. Well, he would see. He selected mercury as a heavy liquid and filled a glass tube with it; then he immersed the open end in a bowl of mercury. The column of mercury dropped at once, but at the height of about thirty inches it stopped and remained stationary. The thing was proved and the scientific world had a new toy to play with.

This scientific toy had, among other things, a perfect vacuum in the space above the mercury column.

Burgomaster von Guericke liked to play with this idea of the vacuum. He wondered if he could create one with a pump. He tried a wooden pump, but the wood was too leaky for air. Then he fashioned a globe of copper, with pump and stopcock, and found he could pump air out as easily as water.

The Burgomaster decided to demonstrate his work on a grand scale so that it would not be forgotten. He constructed two globes of copper exactly alike and polished the edges so that, when put together, they



The Magdeburg experiment. In 1650 Otto von Guericke exhausted the air from two hollow hemispheres and demonstrated before the Emperor and his court that it required sixteen horses to pull them apart. (From a contemporary print)

were absolutely air-tight. At the polar ends of each of these hemispheres he welded a ring. Then he invited the Emperor Ferdinand III and all the princes of the Diet at Ratisbon to come to Magdeburg and witness an experiment.

When they were assembled, he showed the two hollow copper hemispheres. Then he placed the edges together so that they became a sphere. Then he brought out his new air-pump and exhausted the air inside them. Then he asked several of the princes to hold on to the rings in the end and pull the hemispheres apart. All failed.

Then the Burgomaster proceeded, with a great sense of the dramatic, to do what is now known as " knock their eyes out." He had two horses brought out and hitched one to each end of the united globes and started them pulling in opposite directions. The globes stuck together, apparently with nothing to hold them. Two horses were put on each end. No result. Four — six — finally eight horses on each end, straining and pulling. And only then were the globes pulled apart.

This vacuum idea continued to torture inquisitive minds. We have seen the Honourable Robert Boyle and John Mayow working with it. One Hauksbee noticed in 1705 that in the vacuum space above Toricelli's mercury column a luminescence appeared in the dark. This was terribly exciting. Hauksbee found that by rotating an electric friction machine inside an exhausted bell-jar he obtained a periodic purple light.

So, finally, they came together — the electrical discharge and the vacuum.

In 1753 the Abbé Nollet, preceptor in Natural Philosophy to the French royal family, made egg-shaped glass globes and exhausted the air from them. Then he passed electric charges through them. They became luminescent.

The Abbé's " electric egg," as it was called, became a popular scientific toy, finding many applications. One, still successful, was to treat nervous patients. Finally Geissler sealed a platinum disk inside the " egg," and the real fun commenced.

By 1878 Sir William Crookes working with two metallic disks inside the globe, anode and cathode, delivered a whole lecture full of phenomena he could not explain. There were different rays at different pressures. There was a dark spot at the cathode appearing at a certain

point. He thought that what went on in exhausted tubes revealed a new world, "a world where matter may exist in a fourth state."

In the little university city of Würzburg, in Bavaria, William Röntgen, the Professor of Physics, was doing a good deal of investigating with these tubes. He was accustomed to observe the spectrum of ordinary light at its violet end by means of fluorescent materials, the best of which was barium-platino-cyanide. On November 8, 1895 a screen of this material was lying ten or twelve feet away from his Crookes

The Abbé Nollet. His experiments on electrical discharges through vacuum tubes germinated the work which resulted in the X-ray. (By courtesy of the Eastman Kodak Company)

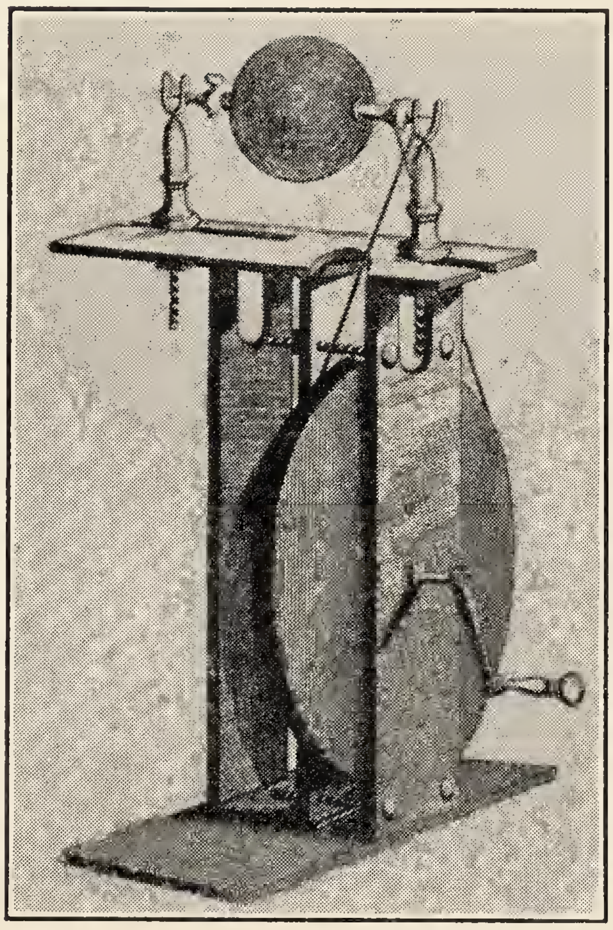
tube when he turned on the electricity, and Röntgen noticed that the barium screen was shining brightly.

Strange, very strange! He was in a carefully darkened room, the only light being inside the Crookes tube, which was completely covered by a shield of black cardboard, impervious to every known kind of light, even the most intense. Yet somehow some kind of light invisible to the eye had penetrated this opaque material.

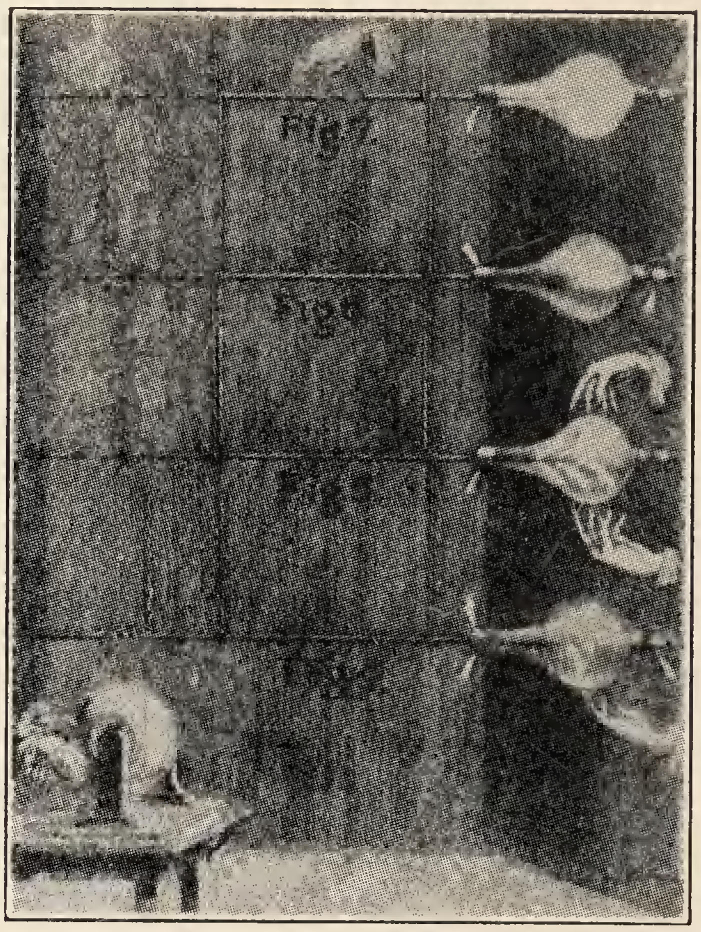
It must have been an exciting moment. But Professor Röntgen kept his head.

Long afterwards, in discussing that moment, Sir James Mackenzie asked him: "What did you think?"

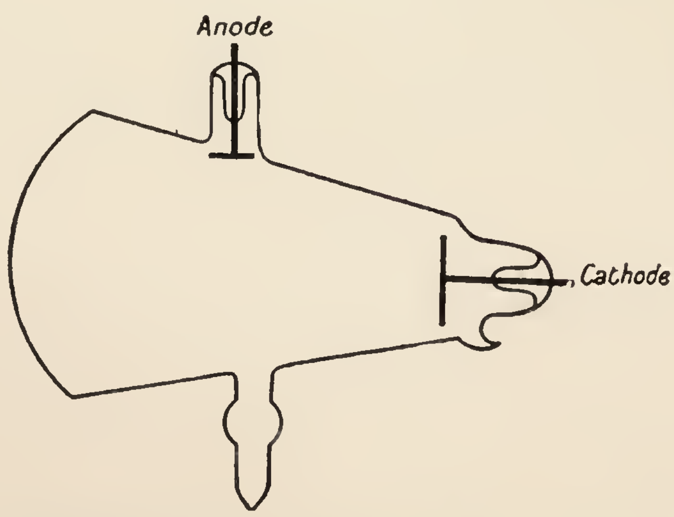
"I did not think, I investigated," replied the professor.[1]



The grandfather of the X-ray. Hauksbee's electrical machine. 1709.



The grandmother of the X-ray. The Abbé Nollet's electric eggs. 1753.



The father of the X-ray. Crookes's tube. 1878.

[1] A flood of legendary stories soon grew up about the way the discovery was made. "The book and key" story was very popular. Professor Röntgen had experimented with a Crookes tube placed over a book, beneath which was a photographic plate in its holder. Some time later he used the plate, and when it was developed, he was puzzled to find the outline of a key on the plate. Then he discovered a key between the pages of the book. It was also said that Röntgen's

Röntgen, the discoverer of the X-ray.

He found that these queer emanations, light-rays or whatever they were, would pass through opaque substances of great thickness — a book of two thousand pages, a plank. A photographic plate inside a wooden box would be light-struck by them.

Professor Röntgen did not know what these uncanny rays were, so he called them X-rays. And X-rays they still are.

One evening in November 1895 Frau Röntgen became huffed at the indifference of her absent-minded scientific husband. She had prepared an especially delectable dinner and he not only made no comment on it, but even did not notice she was angry. When she managed to make it known to him, he smiled and took her downstairs to his laboratory and there showed her the subject of his abstraction. She was the first, besides the discoverer, to see the wonders of the X-rays.

On January 23, 1896 Röntgen described his findings before the Würzburg Physical Medical Society. The discovery made the sensation which it fully deserved in all the civilized world. Minor poets were inspired, as in this example:

X-actly So!

" The Roentgen Rays, the Roentgen Rays
What is this craze?
The town's ablaze
With the new phase
Of X-ray's ways.

I'm full of daze,
Shock and amaze;
For nowadays
I hear they'll gaze
Thro' cloak and gown — and even stays
These naughty, naughty Roentgen Rays."

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laboratory servant actually made the observation which tipped off the discovery. Such tales made Professor Röntgen very angry in after years. " Do you know that now Zehnder heard the story that I did not make the first observation of the effects of the X-rays, but that an assistant or servant discovered them? " he wrote in 1921. " What miserable envious man has invented this story? " The account I have given is that published after investigation in 1897 by Sylvanus P. Thompson in the second volume of the first journal of X-ray research: *The Archives of Skiagraphy*, an English publication whose name was afterwards changed to the *Archives of the Röntgen Ray*.

The secret had leaked out before the formal announcement to the Würzburg scientific society, and in the United States the Cleveland *Plain Dealer* on January 9, 1896 told what it averred was "a singular story," but it added: "vouched for."

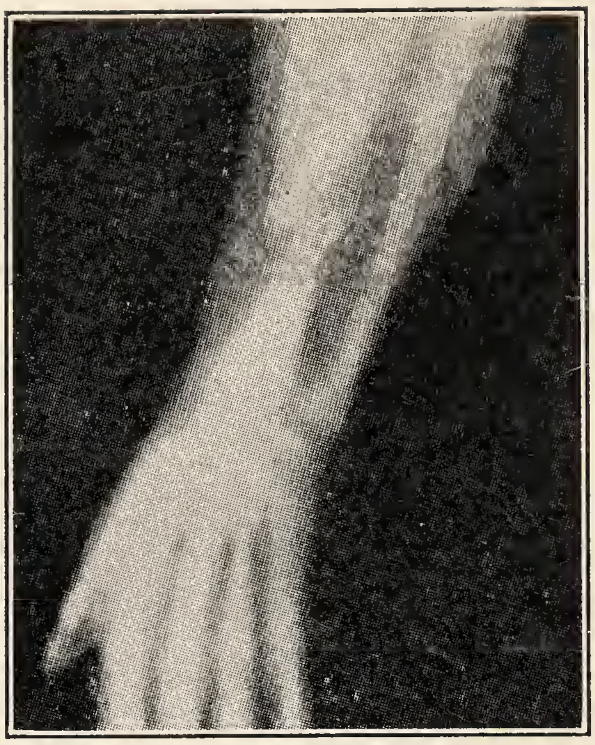
The *Pall Mall Gazette* presented a forthright British judgment on the matter:

"We are sick of the roentgen rays. It is now said, we hope untruly, that Mr. Edison has discovered a substance — tungstate of calcium is its repulsive name — which is potential, whatever that means, to the said rays. The consequence of which appears to be that you can see other

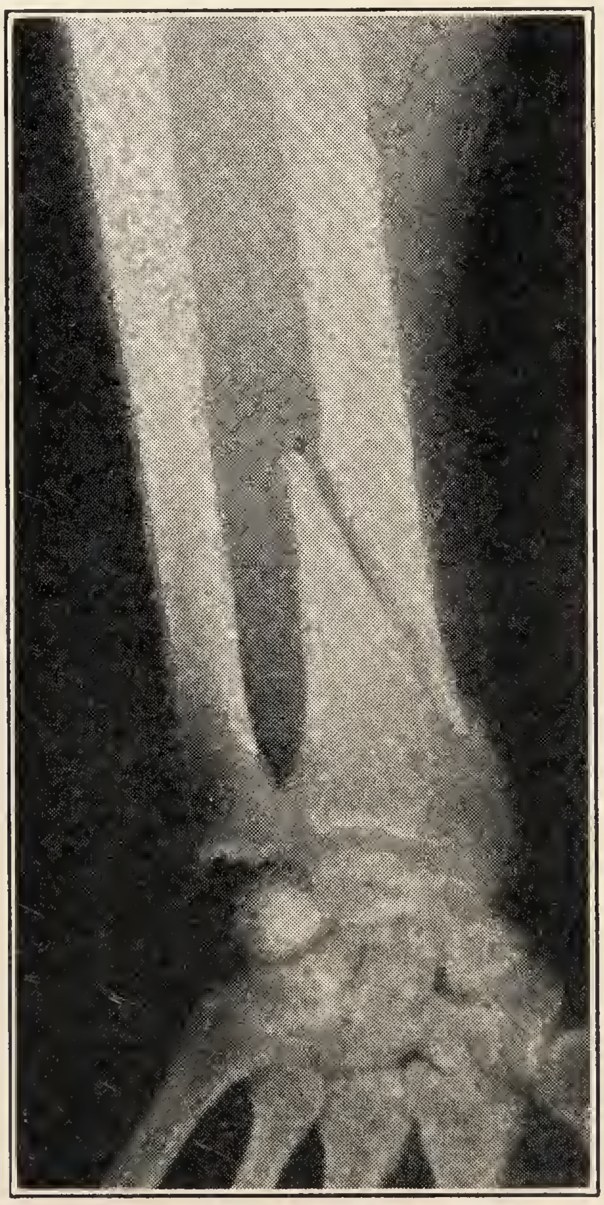
The birthplace of the X-ray. The Physical Institute, University of Würzburg. From a photograph taken shortly after the discovery of the X-ray.

people's bones with the naked eye, and also see through eight inches of solid wood. On the revolting indecency of this there is no need to dwell. But what we seriously put before the attention of the Government is that the moment tungstate of calcium comes into anything like general use, it will call for legislative restriction of the severest kind. Perhaps the best thing would be for all civilized nations to combine to burn all works on the roentgen rays, to execute all the discoverers, and to corner all the tungstate in the world and whelm it in the middle of the ocean. Let the fish contemplate each other's bones if they like, but not us."

It was immediately recognized that the greatest uses of the new ray would be in medicine and surgery. At first its value appeared to be



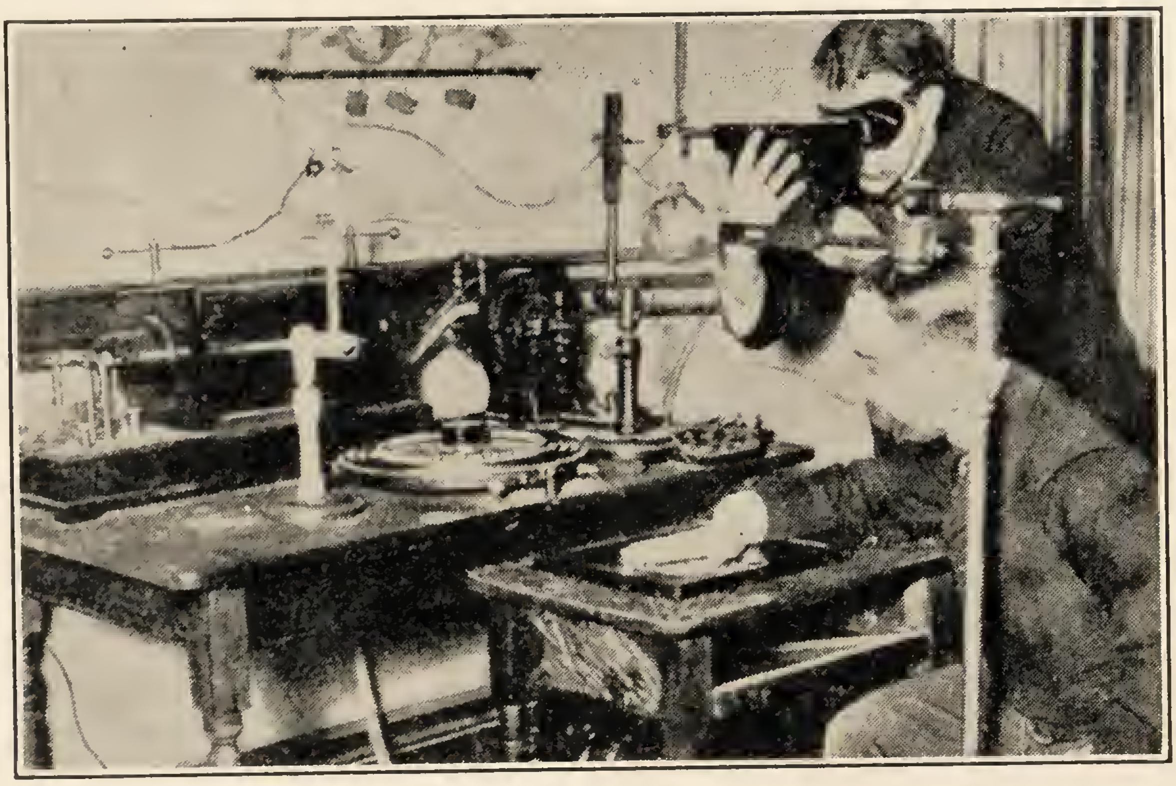
An early X-ray photograph — broken bone of the arm. Note the improvement in technique which has been accomplished, by comparing with the greater detail of the modern X-ray photograph shown below. (By courtesy of Dr. David S. Dann)



confined to bone diseases. The early machines were not powerful, but they showed bones plainly when they were whole or when they were broken or dislocated.

The possibility of observing accurately whether the two ends of a fractured bone were in approximation after the surgeon had "set" them required no argument to persuade surgeons of its value. The improvement that has taken place in the results of treatment of fractured bones is too evident to need emphasis.

"Soft-tissue work" was a sort of watchword of men who worked in the X-ray in the early part of the present century. It meant that they



The infancy of the X-ray. Dr. W. J. Morton at work in his X-ray laboratory, early in 1896. From Radiography and Clinical Photography. *(By courtesy of the Eastman Kodak Company and Dr. Otto Glasser)*

were improving the apparatus so that not only the hard-tissue organs, like bones, but also soft tissues — the lungs, the heart, the stomach — could be photographed so as to show disease.

Dr. W. B. Cannon, at Harvard, demonstrated in the laboratory of physiology, and Holzknecht and Haudek of Vienna in the clinic showed that the outline of the stomach and intestines and their movements could be seen by feeding a meal mixed with a salt, such as bismuth, which throws a black shadow on the X-ray plate.

Today there is hardly a part of the body which is not submitted to the X-ray in the process of a diagnostic examination. Enlargements of the heart, tuberculosis and other diseases of the lung, the stomach and

intestines, the gall-bladder (by using dyes excreted only in the bile), the kidneys (by injecting dye substances into the pelvis), the fœtus in the womb during pregnancy, the teeth, the sinuses of the nose, even the brain — all can be visualized by this strange light.

X-ray examination has not and should not take the place of other diagnostic methods, but it certainly may be said to be one of the five or six greatest discoveries ever made for medical science.

CHAPTER XXVII

PROGRESS SINCE 1900

The characteristic of twentieth-century medicine so far has been the adaptation of the gigantic discoveries of the preceding centuries to common practice.

No great revolutionary epochal discovery has been made in medicine since the X-ray. No discovery or improvement has been made which was not foreshadowed by the work of the past. To make the point specific, surgery has devised many ingenious methods, but all are modifications of the procedures made possible by anæsthesia and aseptic surgery. The diagnosis and treatment of syphilis is probably more changed than any other equally frequent and important disease, but the new methods are founded on the basic work done in immunity, chemistry, pharmacology, and microscopy in the nineteenth and earlier centuries: everyone knew there was a germ in syphilis; Schaudinn simply devised a method to find it. Insulin was so logical an outcome of previous work in diabetes that it must have been discovered as inevitably as an abscess will break pus.

This is not at all to deprecate the value of the work done in the twentieth century or to minimize the credit due to the men who did it. It is to say that the historian finds it difficult to pick out any extremely dramatic and revolutionary events.

What follows is my own idea of the main lines of progress since the beginning of the twentieth century.

1. *Radium and Cancer*

The discovery of the X-rays in 1895 stimulated interest in a group of substances which were known to emit spontaneously some sort of phos-

phorescence, or rays, or energy. In 1896 Henri Becquerel, a French physicist, was experimenting with one of these substances, uranium. Rather idly one day, without much definite objective, he was experimenting to find whether the sun's rays would activate or change uranium so that it would have some effect on a photographic plate. But the sun was disobliging. Clouds came up and it began to rain. Becquerel wrapped the uranium in some black paper, along with the unexposed photographic plate, and put them all in the drawer of his desk.

A few days later he took them out again. Although the plate had not been exposed, he decided to develop it, just for curiosity. He found that the uranium had fogged it, passing through the paper, just as the X-rays would.

Here was something. These radio-active metals, what were they? The word "radio-activity" was suggested by a shy young woman, the wife of Pierre Curie, a Professor of Physics and Chemistry, who was herself an accomplished chemist, though without academic training. She was the daughter of a Polish scientist, Professor Sklowdowski, and had been born in Warsaw in 1867.

Professor and Madame Curie, with Becquerel's encouragement, began to work on uranium and thorium. They found that certain substances were more radio-active than the content of uranium or thorium seemed to warrant. One of these substances was pitchblende. Its occurrence is very rare in nature, the principal source being a mine in Bohemia exploited by the Austrian Government for the extraction of uranium. They were fired with the idea that they could discover a new element. Working against all conceivable odds — poverty, frail health, the difficulties of obtaining the material — they continued, in one of the most heroic struggles in the annals of science, until, in 1898, they isolated radium.

It was a truly magical substance. Why its properties made it so fascinating to chemists is no part of our interest in it; suffice it to say that they did. Everybody wanted to study its properties.

But how in the world did anybody conceive the idea that this substance, which seemed to explain things about atoms and electrons, would cure cancer? The answer involves another accident.

Again the accident involved Henri Becquerel himself. One day he put a piece of radium in his waistcoat pocket. His assistant warned him it might have disagreeable effects on human flesh, but he was heedless and left it there several hours. Eight days later he found a red irritated

spot on the skin of his abdomen. Fifteen days later he stalked into the Curies' laboratory to exhibit this portion of his anatomy and explain, saying: "I love it, but I owe it a grudge."

Pierre Curie wondered whether this Becquerel burn was really due to radium. He bandaged some radium bromide on his forearm and allowed it to remain for several hours. Not until two weeks had passed was any change noticed. Then an area of redness appeared exactly corresponding to the area of application of the radium. A month later the whole area had sloughed out, leaving an ulcer which did not heal for six months.

Well, here was something else. If this metal would painlessly burn off human flesh, why not use it in disease? Curie lent some of it to various physicians of his acquaintance — those interested in skin diseases. In 1901 there appeared the first report on its use in some of these affections.

It soon became evident that its greatest usefulness was in cancer. It has a selective ability to destroy cancer cells and leave healthy ones alone. If left exposed long enough, of course, it burns the healthy tissue also, but during a short exposure it destroys only the cancer cells. The exact mechanism or explanation of this action is still unknown.

The gradual evolution of its use is a story too technical to interest the general reader. Its dangers, its value, the indications for its use, have all been thoroughly worked out. It stands today with surgery and the X-ray as one of the few methods we have for the treatment of cancer. Its particular value is that it can be used in places, such as the cervix of the uterus (the mouth of the womb), where the X-ray cannot be applied and where surgery is known to be limited in usefulness. In small skin cancers it is particularly useful because it can be applied to a small selected area.

2. *Vitamins*

About the beginning of the twentieth century there was a great craze among army boards of manœuvre to secure a concentrated ration — some prepared concentrated food which had enough of all the recognized food elements in it to keep a soldier going for long periods without the disagreeable necessity of calling up the cumbersome commissary. Regiments were camped out in ravines for thirty days, eating only one little cube of food three times a day.

In 1906 a physiologist at Cambridge University, Gowland Hopkins,

put two sets of rats in different cages. They were equal as to age and weight. He fed them differently. The rats in Cage I he fed enough prepared food in the form of protein, fat, sugar, and salts to be considered a balanced diet. The rats in Cage II he fed exactly the same diet, but added a certain daily amount of fresh milk.

The rats in Cage I lost weight and became ill. The rats in Cage II increased in weight and appeared healthy.

Hopkins named the substances in fresh food "accessory food factors."

Thus the idea of the advantages of a concentrated food became dimmed, and cavalry regiments were no longer moved to blasphemy because they were used for such experiments.

Hopkins's work stimulated a great deal of research, and in the hurly-burly some long-forgotten observations made in remote parts of the world were brought once more to light.

Beriberi is a disease confined almost entirely to the Orient. It is a neuritis of the legs and arms with enormous swelling of the feet. As scurvy afflicted the European navies, so beriberi afflicted the Japanese Navy. The Japanese sailor, like much of the Japanese population, lived almost entirely on rice. Rice is a good food: it has 8 per cent protein and 79 per cent carbohydrate. Its fat is low, but its fuel value is 1,590 calories per pound (as against 378 for potatoes, for instance). So that it would look as if so well balanced a food, containing so much fuel value in a concentrated form, would be the ideal one for a ship to carry. But on rice alone the Japanese sailor developed beriberi.

In 1880 a young Japanese physician, Dr. Takaki, had just returned from St. Thomas's Hospital, London, and had entered the Japanese naval medical service. He became interested in this subject of beriberi. He obtained permission to send out two ships under identical conditions — on cruises of the same length, over the same course, with the same strength of crew. Thus climate, period of time, everything was to be the same, except that Dr. Takaki changed the diets on the two ships. The *Ruyajo* furnished its crew of 350 men the regular ration of the Japanese sailor, rice; 100 cases of beriberi developed. The *Tarkula* went over the same course, to New Zealand and South America on a voyage of 271 days, but the crew got meat, vegetables, barley, and other substances — and only 16 cases of beriberi developed, and in every case it was shown that the sailor had not eaten his full allowance of the new foods.

For practical purposes this solved the problem. In 1878 there were 32.8 cases of beriberi per 100 in the Japanese Navy. In 1889 there were 0.03 cases per 100.

But what was the explanation? A large number of the civil population in Japan lived on rice and developed no beriberi. Where was the difference? A Dutch colonial medical officer, named Eijkman, furnished the answer.

Dr. Christiaan Eijkman was sent out to the Dutch East Indies as a young man. The year was 1883. The Dutch Indies are near Java, Batavia, the Malay Archipelago, that largest group of islands in the world, lying south and west of the Philippines. He was appalled at the number of cases of beriberi he found among the prisoners, who were part of his charges.

" As a young colonial official, I lived in Buitenzorg," said the Dutch Minister to the United States, in 1923,[1] " in the neighbourhood of the so-called beriberi hospital, and daily I saw hundreds of the poor sufferers of that mysterious disease passing my home in batches. It was a pitiful sight. Natives, Chinamen, and a few white men dragged themselves along with their swollen legs. They had to take a daily walk, as exercise in the fresh air if possible was in those days the panacea for this disease, wherefor no other cure was found. Many of the numerous cases in the crowded hospital were not even able to walk: they died slowly in the precincts of the hospital, and more than once it happened that some of the patients having their daily exercise collapsed and died on the road of heart failure."

These appalling spectacles caused a commission to be appointed in 1886 to study the disease. Dr. Eijkman was a member. The commission came to the conclusion that the cause was an infection. After the other members of the commission returned home, Dr. Eijkman still remained in the East Indies.

He was not satisfied with the report. He did not doubt then, apparently, that the cause of the disease was a germ. But he had studied with Dr. Koch in Berlin and he wanted to isolate the germ.

He examined secretions, blood, everything about the patient, but still no germ.

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[1] When Dr. Eijkman was honoured by the Franklin Institute of Philadelphia, and was too feeble and old to attend the ceremony, the Dutch Minister accepted the medal for him. Buitenzorg is in Java.

He was appointed director of the laboratories to one of the military hospitals. And continued to study beriberi. One day he noticed some fowls in the yard of the hospital with a peculiar limpness of the neck, and droopiness of the wings, and wobbliness of the legs. Suddenly the idea occurred to him that the fowls had beriberi.

Happiness! Here was an experimental animal. The fowls were fed from the same supply of food that was served to the patients in the hospital. Or, rather, from the leavings.

"The germ of beriberi must enter the body by way of the food" — such was the idea of young Dr. Eijkman.

So he began to experiment. And then inspired stupidity in the role of official economy entered the scene.

A newly appointed superintendent of the military hospitals came on a tour of inspection. He thought it was waste to feed fowls on the food served to patients. He ordered it stopped.

Dr. Eijkman protested. The fowls were being used for experimental purposes — to find the cause of beriberi.

That was all very well, but beriberi had been officially studied already and officially pronounced an infection. No more money could be wasted on that.

So the fowls were ordered to have ordinary rice. Not the "polished" rice — rice with the shell milled off — the way the natives best liked their staple article of diet.

Sadly Dr. Eijkman complied. He went out every once in a while to see his poor experimental fowls. And then something attracted his eye. They were getting better. Their paralysis was disappearing on the new diet.

Could it be that the milling of the rice caused beriberi?

He tried it on two sets of fowls. One got whole rice; the other milled rice. The ones getting whole rice remained healthy. The ones getting milled rice developed paralysis.

Well, there it was. No germ at all — some substance in the shell of the rice grain.

Eijkman found that the custom of "polishing" the rice was regular in the prisons. It was supposed to be a more palatable way of serving it. The polishing process milled off the thin outer layer of husk. The same custom of using only polished rice prevailed also in the Japanese Navy in the old beriberi days. So Eijkman began to serve unpolished rice to

certain prisoners in the Dutch East Indies. When he got through, he had the following table:

In 37 prisons unpolished rice was served; in only one prison cases of beriberi occurred.

In 51 prisons only polished rice was used; in 36 prisons cases of beriberi occurred.

Reckoned for 10,000 prisoners:

(a) With unpolished rice, one case.

(b) With polished rice, 3,900 cases.

"Some years later," continued the Dutch Minister, in that address from which we have already quoted, "the beriberi hospital at Buitenzorg was closed for want of inmates."

Eijkman's work was done from 1889 to 1897. In 1911, when Casimir Funk was able to extract the anti-beriberi element from rice polishings with alcohol, he named it "vitamin." That name applied to all Gowland Hopkins's "accessory food factors" has stuck.

Since 1911 an immense amount of work has been done on the vitamins and the "deficiency diseases," as they are called, caused by the absence of vitamins from the dietary.

While their exact chemical nature is still unknown, many of the characteristics of these vitamins have been experimentally proved. They are found in different kinds of fresh foods — meat, especially fish, green vegetables and fruits, milk and eggs. It is probable that man and many other animals adapted their organisms, through the process of evolution, to depend on them. We are, therefore, now not fit to live on preserved and concentrated foods — for which all praise and power to His Holy Name, so far as I am concerned.

Some of the vitamins are soluble in fat and are found in fat foods; some are soluble in water and found in vegetables and fruits. Thus water-soluble B vitamin is found in coverings of grain — wheat, barley, and rice — and milk and yeast, and its presence in the food prevents beriberi. Water-soluble C vitamin, present in lemons, oranges, limes, and green vegetables, prevents scurvy. Fat-soluble D vitamin is found in cod-liver oil and fish oils and can be artificially prepared by exposing oils to sunlight — viosterol. It prevents rickets.

Rickets and scurvy — both examples of deficiency diseases — are still very common in children. Since Vitamin D is less likely to be present in the food of an average diet than any other vitamin, it should be de-

liberately added to children's food in the form of cod-liver oil, halibut-liver oil, salmon-liver oil, or viosterol. Scurvy in infants is mostly found in children who have been fed exclusively on condensed milk.

3. *Syphilis*

Syphilis is unique among diseases. All the others either appear within a limited area of the earth's surface (for example, such tropical diseases as sleeping sickness), or, with slight variations in respect to race, age, and sex, have always afflicted mankind wherever he lives, since the earliest definite records of history. A few human diseases have appeared suddenly, and apparently for the first time during the historical period, but their origin and the reason for their sudden appearance are well known; such, for instance, is the comparatively recent Malta fever, or undulant fever, which came from infected milk herds — first, goats on the island of Malta, later spreading to cows in other countries.

But syphilis did none of these things. A disease, which, for all practical purposes, may be said to be exclusively human, and to which human beings of all ages and races and both sexes are exceedingly susceptible if exposed, it appeared for the first time in the late fifteenth century. At that time, we must believe from contemporary accounts, its effects on the human frame were so much more violent than at present that it constituted a pestilence comparable to the Black Death. People actually died during the eruptive stage, a circumstance unheard-of now, even if no treatment is instituted.

It was apparently far more widespread even than it is now: Thierry de Héry, one of the early "specialists" in the treatment of the malady, knelt before the statue of Charles VIII at Saint-Denis, saying to a bystanding priest: "Charles VIII is a good enough saint for me; he put thirty thousand francs in my pockets when he brought the pox into France."

When it did appear, then, for the reason both of its malignity and of its universality, it certainly did not escape notice.

This sudden appearance of the disease in the late historical epoch has given rise to much discussion and debate. What is the explanation?

Well, in the first place, the facts as stated are denied — and by weighty historical authority. It is claimed that syphilis has always existed, but was unrecognized until about 1500. But this argument is not very easy to accept: syphilis is an easy disease to recognize; its symp-

toms and signs are dramatic in the extreme. Its effects upon the human structure are widespread and characteristic. If it did exist since the earliest historical period in western Europe, it is inexplicable that in all the ancient writings — the Bible, the papyri, etc., which contain hundreds of descriptions of diseases not difficult to identify under their modern nomenclature — tuberculosis, leprosy, cataract, etc. — there should be no mention of a malady which since it first did appear has so absorbed the attention of mankind.

Add to this the fact that its appearance in 1500 attracted immediate interest. Quite evidently everyone agreed that here was something new to medical experience. So rapidly did it spread that it seems impossible to believe it had existed hidden and unknown for any length of time. The account of Villalobos (1498), probably the earliest, begins with the words:

> " A curse that ne'er before had reared its head to strike,
> Nor had been sung aloud by poet, priest, or sage."

Nor were any of the most characteristic features of the disease missed by the early describers. That the contagion was acquired preponderantly during sexual intercourse, that the early lesions appeared on the genitalia, that the eruption and febrile manifestations followed in regular order, and other features known to accomplished diagnosticians are all meticulously recorded in the early writings of Villalobos (1498), Almenar (1502), Johannes de Vigo (1514), Ulrich von Hutten (1519), and Fracastorius (1530).

The most widely quoted explanation is that it was native to America and was acquired by the crew of Columbus from native women and brought by them to Europe. Many circumstances strengthen this hypothesis. The date of its European appearance is one. A number of curious incidents which occurred on shipboard on the returning vessels are, at least, highly suggestive. Its spread corresponds to the invasion of the Spanish Army into Italy at the siege of Naples in 1495, and to the return from that campaign of the French Army to its own land.

This supposition has been opposed by one of the most learned of medical historians, Dr. Karl Sudhoff. Dr. Sudhoff believes the epidemic which appeared at Naples was typhoid fever. The evidence is too complicated for anyone but a very patient historian to examine. And except for its inherent interest the question is of little consequence.

The clinical knowledge of syphilis accumulated in waves. Early in its history mercury was discovered to be very potent in curative powers. The disease was, for a time, declared to be the same as the other common venereal disease, gonorrhœa. In order to test this, John Hunter actually inoculated himself with pus from an active gonorrhœa. He developed syphilis in his own person and probably the inoculation hastened his death. He described the initial lesion, which is still called the " Hunterian chancre." His experiment being conducted under confused circumstances, he believed that he had proved the unity of the two diseases. This mistake was corrected by Ricord in the nineteenth century. The congenital forms were clearly described by Jonathan Hutchinson during the latter part of the nineteenth century.

The last wave of research occurred in our own time. In 1905 Schaudinn discovered the specific cause of syphilis, a protozoan parasite called "*Spirochæta pallida*" or, more properly, "*Trepanoma pallidum.*" In 1906 Wassermann, using the Bordet-Gengou phenomenon, introduced the Wassermann test of the blood as a definite method of diagnosis. In 1910 Ehrlich introduced a more potent drug for treatment, the arsenical preparation salvarsan, or 606. In 1917 Wagner von Jauregg introduced the malarial or febrile treatment of the late nervous manifestations, such as paresis. In 1922 Sarazec and Levaditi introduced bismuth as a curative drug, which has rapidly made a place for itself and is probably, though less heralded than salvarsan, the most valuable of all methods of cure.

The stories of these discoveries are all interesting, but most of them have been so well told by Paul de Kruif in *Men Against Death* that repetition on my part would be an impertinence.

4. *Diabetes*

Diabetes, unlike syphilis, is a very old disease. We have descriptions of it going back to classical antiquity. One of the difficulties in reading the ancient authors is that they seldom formulate a clear-cut description of a disease. When an Italian calls a disease "*fugore,*" a Frenchman "*cynanche trachealis,*" a German "*epidemisch hals smerchz,*" and an Englishman "malignant ulcerative sore throat," all give about the same vague symptoms, and all propose different remedies, it is hard

to discern any progress. But the name diabetes was early applied by all authors to a characteristic set of symptoms.

Aretæus, the Cappadocian (A.D. 30–90), said: "Diabetes is a melting of the flesh into urine." He added: "The thirst is ungovernable."

This triad of symptoms — loss of weight, excessive urine and thirst — persists in all descriptions of the disease. But what was the cause? Why did the flesh of the body suddenly begin to flow off in this flood of urine? The problem made doctors cudgel their brains for two thousand years.

The solution came very gradually. Willis showed that the urine of diabetics was sweet, and Mathew Dabson proved that the abnormal substance present was sugar. Physiologists worked out the fate of the starches in the body and showed they were all turned to sugar before being utilized for energy. All the sugar in the normal body is completely used up, burned, oxidized, so that none flows off in the urine. What happens to the diabetic body that this process is interrupted? Naunyn by an inspiration guessed, and Minkowski proved in 1888, that the pancreas furnishes a substance which burns sugar in the body.

When the pancreas is removed from an animal, it dies of diabetes, said Minkowski. Now, why is that? The pancreas plays a very important part in digestion. It throws an abundant digestive secretion into the intestine. Is it because the digestion is impaired that diabetes develops? No, said the laboratories, because when the pancreatic duct is brought out on the surface of the body, and the secretion flows away, diverted from the intestine so that it can perform no digestive function, the animal does not develop diabetes. In 1869 Langerhans showed that the pancreas contains some nests of cells which are not associated with the digestive cells. In 1900 Opie showed that in diabetic patients these cells are diseased.

So the matter stood, then, up to 1920. The theory of the nature of diabetes was that sugar is burned in the body by the action of an internal secretion of the Langerhans cells — a substance thrown into the blood directly. When these cells are diseased, this oxidation of sugar fails; the sugar accumulates in the blood and is carried to the kidneys, which, being sensitive to an excess, carry it off. That is why the urine is full of sugar in diabetes. The excess sugar needs a good deal of water to keep it dissolved and hence the patient is thirsty. The increased intake

of water results in an increased output. The loss of weight is due to the body attacking its own tissues to obtain the energy it should get from the sugar of the food.

The danger of severe diabetes was found to be directly attributable to the decreased sugar oxidation. Most severe cases of diabetes died in a peculiar comatose condition, described fully by Kussmaul, one of the greatest physicians of all time, in 1874. The coma was proved to be due to the accumulation of fatty acids, resulting from the incomplete burning of fats. The fats will burn completely in the body only if glucose is also being burned.

The treatment in 1920 was largely based on the principles laid down by Naunyn and was a logical outcome of the conception of the disease which I have just stated. If the patient cannot burn as much glucose as a normal person, do not let him eat as much. It was found that all diabetics can utilize *some* glucose.

But the condition of the severe diabetic even under the best treatment in 1920 was pretty miserable. He was kept on a starvation diet, was always underweight, weak, and hungry. And do what one would, he would tend to drift towards coma, was always on the ragged edge of that state, which was invariably fatal.

Well, if lack of the internal secretion of the pancreas was the cause of the disease, why not give the patient some pancreas? We did. We gave it by mouth and made extracts of the pancreas and injected these under the skin of diabetics, but no good came of it. So regularly were such experiments negative that special students began to doubt whether the Langerhans cell theory of the origin of diabetes was correct.

" In the year 1920, a young orthopedic surgeon located in London, Ontario. He had spent four thrilling years in France with the Canadian army, his war experience consisting largely of efforts to make maimed and mutilated men into useful members of society. So it was only natural, perhaps, that when the World War was over, he should continue this work and attempt to do in peace times what he had done during the war.

" Banting tells us that his entry into practice was not attended by any phenomenal success. He kept office hours faithfully and regularly for twenty-eight days before his first patient presented himself and, at the end of the first month, found exactly four dollars on his books! To employ his spare hours, which were many, he obtained a position

as demonstrator of physiology at the Medical School of the University of Western Ontario. This gave him an opportunity to work in the laboratory and, also, as every teacher of students knows, made extensive reading necessary.

"One evening in October, 1920, Banting, while preparing for his class work, read an article by Moses Barron in 'Surgery, Gynecology and Obstetrics.' This article described some experiments in which the pancreatic duct in dogs was ligated, producing a complete atrophy of the acinar tissue, but no change in the Islands of Langerhans. After reading this interesting article, he went to bed, but found that he could not sleep and presently an illuminating train of thoughts followed. If the Islands of Langerhans contained an internal secretion, why not perform such an experiment as Barron had described and, after all but the islands had degenerated, remove the pancreas and extract this secretion. After lying in bed for a time, he got up, found his notebook and wrote in it: 'Ligate pancreatic ducts of dogs. Wait six or eight weeks for degeneration. Remove the residue and extract.'

"Banting probably feared that on the following morning he would forget all about it. But there was no danger of this. In the early part of the nineteenth century, Sir William Gull, in commenting upon Frederick Pavy's investigations in diabetes, asked 'What sin has Pavy committed, or his fathers before him, that he should be condemned to spend his life seeking the cure of an incurable disease?' Banting, from this time, to paraphrase Gull's remark, was doomed to seek the cure of an incurable disease.

"The young orthopedic surgeon seemed to forget his interest in crooked legs and ankylosed joints — and was obsessed only by the thought of curing diabetes. He discussed the problem with his colleagues, and, upon their advice, went to Toronto, where he told of his plans and hopes. At Toronto he was received courteously but asked frankly how he, an orthopedic surgeon, with no particular scientific training, could hope to solve a problem which had baffled the greatest minds in science for centuries.

"Banting returned to London a trifle discouraged, but as determined as ever to follow up his thought which had become such an obsession. After turning the whole matter over in his mind, he suddenly made a bold move; he closed his office, sold his surgical instruments, and went up to Toronto to work at this problem which had tormented

him for months. In the laboratory at Toronto, he was assigned a place and was told that he could have a medical student to assist him in his work. Two students applied, but since there was room for but one, a coin was tossed, and Charles H. Best, a second year medical student, won the toss and started to work." [1]

That toss of a coin won for Best a place among the medical immortals.

At first they encountered the disappointments of all the other defeated investigators in the same field — "the lost adventurers, their peers." They worked on dogs rendered diabetic by removal of the pancreas. In their early experiments they used the extract from the pancreas of dogs in which the duct had been tied before removal from the body. They had just enough success to make them hopeful, to make them feel they were on the right track. But the extract was very feeble.

Brooding constantly over the difficulties, resolved that he must be able to solve the enigma in a practical way, Banting read all the literature on the pancreas he could get his hands on. Then, one fortunate moment, he came across the obscure account of Laguesse, who had found the pancreas in new-born babies to be full of islet of Langerhans cells, but poor in the digestive cells of the pancreas.

That was it. That was the heart of the problem. The digestive cells of the pancreas, after the duct was ligated, turned the powerful digestive juices inwards, destroyed the islet cells before they could be extracted.

The way round the difficulty was plainly indicated by Laguesse's findings — use new-born or unborn animals in whom the pancreatic digestive cells were undeveloped. The investigators then began to use the pancreas from unborn calves. To kill whatever digestive potency these organs had, the investigators tried putting them, immediately on removal from the body, in acidified alcohol.

They got results — beautiful, perfect results. Injected into diabetic dogs, this substance reduced the high blood sugar. The sugar disappeared from the urine. The dogs lived days, weeks, and months beyond the time when untreated they would inevitably have died from diabetes.

After success in dogs, the supreme test — whether it would be effective in human patients with spontaneous diabetes (as opposed to the artificially produced diabetes of the dogs). Banting, as was natural, wanted the credit of giving the first dose in man. Best prepared the

[1] Quoted from Dr. Ralph H. Major in an article in a medical journal.

extract. Then, ludicrously, the first patient refused to allow the dose to be given — "didn't want to be experimented on." But others were found, among them a physician with severe diabetes — Dr. Gilchrist. It worked! It was as potent in human beings with natural diabetes as in animals with artificial diabetes. Dr. Gilchrist, who rejoiced in the title of "rabbit-in-chief," has told of his sensations after his first dose of insulin — a definite sense of renewed vigour and strength surging through his body. I have had patients since then tell me the same thing. One said: "The next morning I felt, for the first time in weeks, as if there was something in my body that hadn't been there before. Something the body needed. I was all there. I sang in the bathtub for the first time in months."

The substance was at first called "iletin," the name afterwards changed to "insulin."

Its discovery was announced in 1922. Every physician who has been practising ten years remembers the thrill of that announcement. I recall my own sensations vividly. I saw in a medical journal something about "the good news from Toronto." I didn't know what it was. I asked twenty men before I found out. It made me positively happy, elated — like falling in love, or being left money, or hearing the news of the armistice.

The success of its practical application has exceeded all expectations. In severe forms of diabetes — in children and young adults — it is life-saving. And perhaps even better than that, it keeps them comfortable and happy — not in a condition of semi-starvation, as the old forms of treatment did. Diabetic coma, before its advent, was invariably fatal. Now recovery from coma is a commonplace. I had three patients enter my hospital service this fall in profound coma. All recovered. Before 1922, all would have died.

Like all great discoveries, it can be given by anybody, anywhere. Patients give it to themselves. This does not mean that patients should attempt to treat themselves — diabetes is still a complicated disease. But, like the best discoveries of medical science, insulin, instead of creating a specialty, tended to turn patients back to the general practitioner.

5. *Pernicious Anæmia*

When you are in London some time and tire of the most famous sights, walk up the Strand, along Fleet Street, pass to the right of St. Paul's Cathedral, and find your way to London Bridge. Pass over this to the other side of the Thames. You will be in the part where Shakspere's plays were first enacted, and soon you may stumble into a narrow street which brings you to a low, dark, rambling building with a paved courtyard in front and a small statue in front of the main entrance.

You will be standing in front of one of the most famous hospitals in the world — Guy's.

Here, during the early years of the nineteenth century, one of the attending physicians was Thomas Addison. He was a real doctor, as may be seen from this reminiscence of him:

"He has also been known, after seeing a patient within the radius of eight or ten miles, to remember on his near approach to London, thinking over the case on his way, that he omitted some seemingly important inquiry, and to have posted back some miles for the purpose of satisfying his mind on the doubt which had occurred to it."

In 1855 he published a paper which described two diseases — one of them known pretty well by his own name — Addison's disease — the other "a very remarkable form of anæmia," in that it occurred "without any discoverable cause whatever . . . no previous loss of blood . . . no malignant disease. . . ."

Also he noted that it occurred "generally beyond the middle period of life."

It was the disease now called "pernicious anæmia."

The most that could be said about it up to 1925 was that it appeared to be one of the degenerative diseases of elderly people. The organs wear out and nature, by her own processes, gradually removes the actor from the scene. Such diseases are Bright's disease, in which the kidneys degenerate; and that combination of conditions — high blood-pressure, hardening of the arteries, degeneration of the heart, apoplexy — in which the blood-vessels wear out.

In pernicious anæmia the organs which seem to be the seat of most of the wearing out are the stomach and the bone marrow. The stomach

in such a patient furnishes absolutely no secretion whatever. The bone marrow which produces the red blood-cells atrophies and loses its characteristic red colour and stops (at least, almost stops) producing red cells.

The proper treatment before 1925 was to give the patient hydrochloric acid to replace that substance which the stomach normally produces, some arsenic to stimulate the marrow, and possibly transfuse some good blood into the blood-stream. Under that treatment the results were quite uniform. Almost without exception the patients went on about four years and then died. Every once in a while a patient would be reported who lived seventeen or twenty years, but such were considered exceptions.

In Boston in 1925 or thereabouts a young physician, Dr. George R. Minot, began to work on the notion that patients with pernicious anæmia did not eat much meat. He interested another young physician, Dr. William P. Murphy. Together they made pernicious anæmia patients gorge on animal proteins. In looking for complete and concentrated articles of diet of this sort they thought of liver. So they made their patients eat half a pound of liver a day.

Liver is not a particularly attractive dish to most people, but the patients of Doctors Minot and Murphy found that they could learn to like it because as soon as they began to eat it, the anæmia cleared up. They felt better and their red blood-cell counts increased.

In 1926 these results were reported, and physicians all over the world began to force liver on their pernicious anæmia patients. Any doubts which had existed of the efficacy of the treatment vanished as the patients universally got well and stayed well.

They have stayed well ever since, and that is twice as long as the usual term of life of the pernicious anæmia patient before the introduction of the liver treatment. Some of them have perished by being run over by automobiles, or from pneumonia, old age, or other intercurrent affections, but, with few exceptions, they have not died of pernicious anæmia.

Here, then, for the first time in history, is a degenerative disease of middle life which has been arrested by treatment. And that is the significance of the discovery. Perhaps all the apparently inevitable processes of mortal decay can be arrested.

6. *Disorders of the Ductless Glands*

During the twilight of the eighteenth century a distinguished-looking gentleman was frequently to be seen on the parade of the city of Bath in England. Bath, being a spa, a haven for invalids, was naturally a good place for physicians. This distinguished gentleman was the most prosperous of the Bath physicians. He was Caleb Hillier Parry, the friend of Jenner, to whom Jenner dedicated his famous *Inquiry.*

As a proof of his popularity and of his first-hand acquaintance with sick people, a story is told that a friend met him one evening on the street and noticed that his waistcoat pockets were bulging.

" I presume," said the friend chaffingly, " those are guineas you have collected today."

" Yes," responded Dr. Parry, " there are ninety-nine of them. I am thinking of making it an even hundred before I go home."

With so large an experience of observing sick people it is not surprising that he should have found something new. It is surprising that so striking a picture of disease as exophthalmic goitre should have waited until 1786 to be recognized. The title of his paper, which was first published posthumously in 1825, is " Enlargement of the Thyroid Gland in connection with . . . palpitation of the heart." It indicated, for the first time in history, some idea of what that hitherto mysterious organ the thyroid gland does. When diseased, it causes the heart to beat rapidly, observed Parry.

Later Robert James Graves reported similar cases, and until Parry's paper was unearthed by William Osler, it was generally called " Graves' disease " in England. In Germany it is called " Basedow's disease " after Karl A. von Basedow of Merseburg, and in justice it must be said that the first crisp description of the three cardinal symptoms, " the Merseburg triad " — enlargement of the thyroid, prominence of the eyeballs, and rapidity of the heart rate — came from his paper, published in 1840.

With the thyroid, at any rate, all our knowledge of the functions of the ductless glands began. These organs were puzzling enough to the early anatomists and physiologists — so puzzling, indeed, that they couldn't even argue about them. They were easy enough to see. It was not because they were overlooked that they went undiscussed. It was

simply that no one could possibly imagine anything they were good for. One or another would have been called the seat of the soul except for the fact pointed out by learned theologians that animals had them, too.

Here they were — fleshy masses, plainly functioning tissue (that is, not atrophied vestigial structures). Glandular, evidently. Yet, other glands secreted something like saliva or pancreatic fluid through a duct into a cavity. These things had no ducts. What did they do and how?

The earlier physiologists had plenty to occupy their attention without thinking about the ductless glands, so they didn't. They simply ignored them — left them completely out of their books. The obvious way to find out about them would be to remove them from an animal and watch the result to see what it lacked — what functions were missing. But aseptic surgery had not been invented then — the animal would have died of infection before any observations could be made.

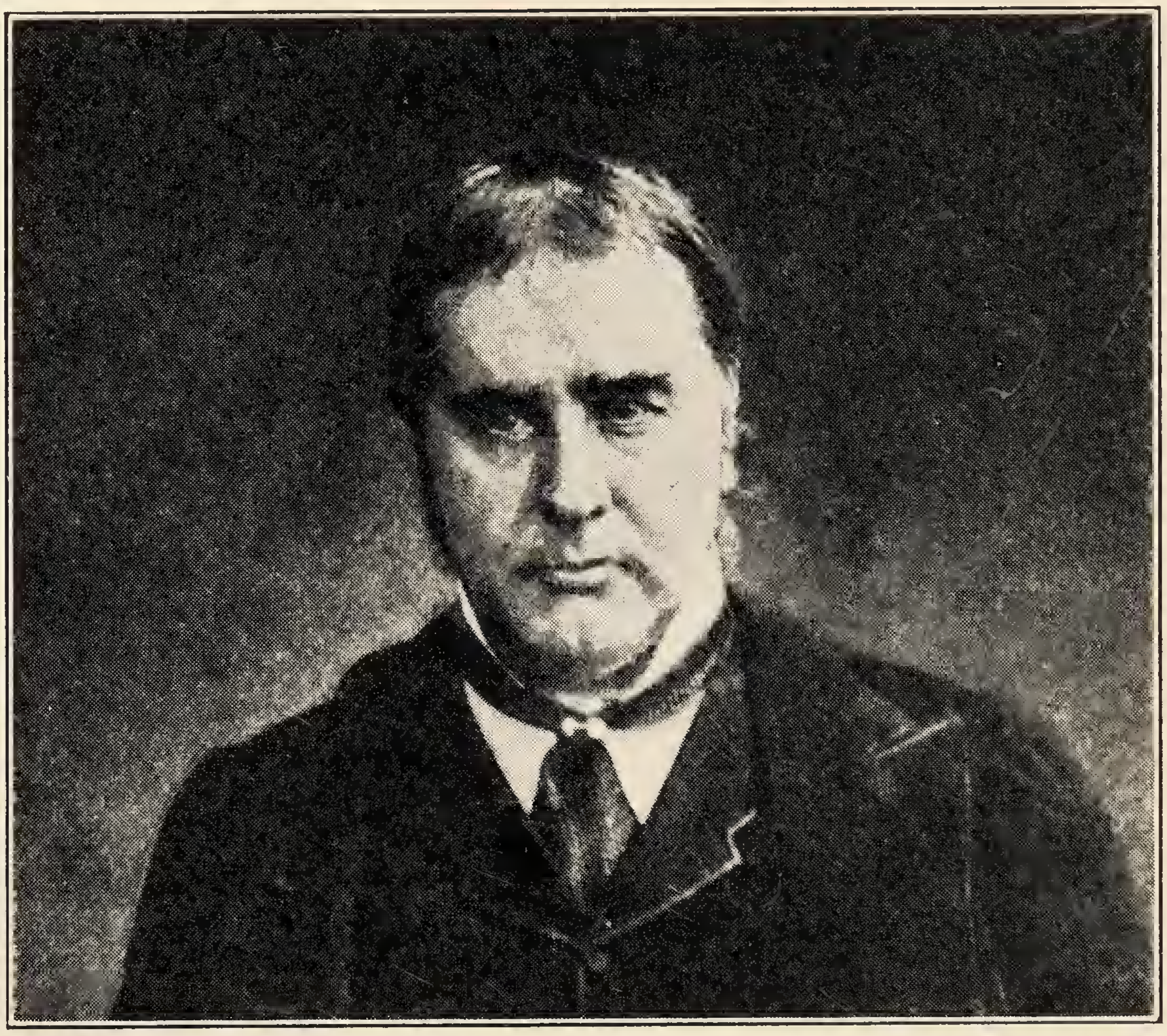
So it was by the door of clinical observation that we came to know of them — by seeing what happened when they were diseased. It was natural to conclude that in the cases described by Parry, Graves, and Basedow, since the thyroid was enlarged, it was furnishing an excess of its secretion. Exactly who first plainly expressed the idea that these glands functioned by throwing their secretion directly into the bloodstream, the reason for their lack of ducts, I have not been able to discover. But it became firmly established.

When the thyroid gland became enlarged, the patient often was hot, excited, trembling, nervous, thin, with rapid heart action and staring eyes.

A condition which was just the opposite — cold, sluggishness, heaviness, torpor — was described in children by Curling in 1850 and called "cretinism." Then Gull, in 1873, described a similar condition in adults. He only suggested an association between it and the absence of the thyroid, but in 1883 Reverdin, of Geneva, produced the condition in dogs by the experimental extirpation of the thyroid gland.

Theodor Kocher of Bern had followed the lead suggested by the study of goitre and, in 1878, was the first to remove the thyroid gland as a deliberate surgical procedure. When Reverdin reported his results, Kocher had performed the operation one hundred times, and in 1883 stated that a condition called by him "cachexia strumipriva," which was really myxœdema, supervened in thirty of his patients.

See now how previous work paves the way for practical results. This cold, sluggish state of body — myxœdema — was described as the result of observation on patients, then it is proved to be due to loss of the thyroid gland, first experimentally in animals, then as an accidental result of surgery in human beings. Now George Murray, of Durham, bethought him that if myxœdema is due to loss of thyroid secretion, why not give a patient with myxœdema some thyroid gland to eat and see



William Gull. "We have no system to satisfy, no dogmatic opinions to enforce. We have no ignorance to cloak, for we confess it."

if this replacement would effect a cure. In 1891 he tried it on his first case, using the thyroid gland of a sheep.

The result exceeded all expectations. In three months a woman whose face was "blank and expressionless, the features notably thickened," disinclined to see strangers, always complaining of cold, slow of speech, heavy of body, was transformed into a normal human being again — the swellings of the face and body gone, the speech rapid and fluent, mind and memory active, the movements active, delight in labour returned.

No wonder such magic roused imaginative men to a high pitch of enthusiasm. In the meantime Addison had described a disease of another

of the ductless glands — the adrenal. Then, in 1885, Pierre Marie described the occurrence of sudden enlargements of parts of the body, beginning in adult life — hands, feet, jaws growing, the whole body growing, giants — due to disease of the pituitary body. Then Fröhlich in 1901 described a sort of sexless creature whose condition was due to another disease of the pituitary gland.

It looked like the crazy dream of a fairyland where idiots were turned into geniuses, men into women, women into men, giants grew, and stunted dwarfs were produced at will. Alice read on the bottle in Wonderland: " Drink me," and she did, and grew and grew. It seemed that medicine had blundered into a wonderland.

If it hasn't turned out just as expected, and most of us are still in the humdrum old world as it always was, at least the realities as we know them are far beyond anything Caleb Hillier Parry, walking the solid streets of Bath with his waistcoat full of guineas, could have imagined.

An immense amount of research and speculation has gone on about the ductless glands during the twentieth century. Societies have been formed of those interested in the study, magazines devoted to the discussion of this subject alone have been established, books, articles, and encyclopædias written by the score.

In general, the studies may be said to fall into two classes — solid investigation and arm-chair speculation. There has been plenty of the latter.

The solid investigation has been carried out on three lines. First, isolation of the secretions of the various ductless glands, capable of being used for replacement therapy. Second, investigation by physiological and surgical experiment. Third, clinical observation.

The difficulties in the way of preparing potent extracts of these glands have been overcome only with considerable effort. When thyroid gland — simply the raw gland swallowed like food — was found to be effective in conditions of deficient secretion of that gland, it prophesied a false sense of simplicity for the whole situation. It was the first gland extract tried. Not one of the others proved successful given in this fashion. As we know now, the principal reason for this was that none of the others is effective when taken by mouth: they are all destroyed by the stomach juices. And extracts of the raw glands cannot be given hypodermically because they cause violent reactions — chills, skin eruptions, etc.

What was required was a crystalline (non-protein) product, which meant the extraction of the pure chemical which actually did the work of the gland. And in each case this was a problem in biological chemistry of staggering complexity. In nearly every instance, however, it has been accomplished.

The first of these hormones, as they are called, to be isolated was that of the interior or medulla of the adrenal gland. The adrenal is, in reality, two glands of entirely separate structure and function. The substance crystallized from this part of the gland is called "epinephrine," or, more commonly, "adrenalin." Abel (1897) and Tahiki were the early workers, and Abel finally devised a method of preparing it synthetically — not using the gland at all. It acts as a drug, effective in asthma shock and other conditions.

In 1914 Kendall, at the Mayo Clinic, isolated the hormone of the thyroid gland in crystalline form. It is named "thyroxine."

The pituitary gland is also not a single gland, but three. From the posterior lobe an active substance, called "pituitrin," has been isolated, owing to the work of several investigators — Oliver and Schäfer, Dale in 1906, and Abel. It acts as a drug effective in obstetric practice, intestinal paralysis, and also diabetes insipidus.

In 1922 Banting and his co-workers, as we have seen, announced the isolation of an effective extract of the Langerhans cells of the pancreas, called "insulin." It has had marked success in diabetes.

In 1925 Collip isolated the active substance of the parathyroid glands, called "parathyrone." It has been successfully used in tetany.

In 1930 Swingle and Pfiffner isolated the active substance of the cortex of the adrenal gland, called "cortin." It has been successful in Addison's disease.

The active substance of the anterior lobe of the pituitary gland was extracted by Evans and Long in 1921. It goes under various names, commonly "antuitrin." Its value is not fully established, but it seems probable that one part of it (the "S" factor — sexual) will prove effective in certain conditions of derangement of the sexual glands upon which the anterior pituitary lobe exerts a regulatory and stimulating effect. Another portion (the "G" factor — growth) has been used to promote growth in dwarfs and undersized individuals.

Extract of the female sex gland, the ovary, was made by Allen and Doisy in 1923. It is called "theelin." Its use in treatment has been rather

disappointing, owing, apparently, to the rapidity with which it is excreted from the body. In treating the symptoms of the menopause it has been more successful than in other conditions.

No active substance has been isolated from the male sex glands, the testes, nor has the feeding of the whole gland or the surgical implantation of grafts resulted in any benefit, *Black Oxen* and other pieces of fiction to the contrary.

Other investigations are too numerous to describe in detail. Among American contributors, Dr. Harvey Cushing, whose long and brilliant career in surgery has been devoted to the logical extension of the method of the great physiological surgeons whom he succeeded — Horsley, Kocher, and Halstead — co-ordinated the knowledge of the pituitary gland. Marine and Kendall showed the possibility of preventing simple goitre by the administration of iodine in geographic regions where the soil and water are deficient in that substance. David P. Barr (1930) described a set of symptoms associated with increased secretion of the parathyroid glands, and demonstrated the astonishing regression of bone tumours on removal of enlarged parathyroids. The late William Engelbach left as his legacy to the world the results of a long and patient research into the effects on the body of the function and cyclic activities of all the glands.

7. *Psychological Medicine*

Medicine absorbed some of its legitimate charges slowly. Women in childbirth were recognized as best cared for by medical science, as we have seen, only within a late period of history. The diseases of the teeth, strictly speaking, have not yet been regarded as part of the physician's concern: there is hardly a medical school extant which offers an adequate course on the subject.

Mental diseases were among the very last to enter into the physician's province. The unfortunate patients were given over to the police and priests instead of doctors. They were " loaded with chains and tied with ropes like convicts. They were at the mercy of their keepers, and their keepers were malefactors from the prisons." These were the words spoken over the grave of Pinel, the man who put a stop to all such practices. In 1791 he inaugurated the modern sanatorium — humane restraint — treatment of the insane.

There is another large group of people who, though not mentally unbalanced, are yet not mentally sound. They include those who are never well enough to work, who are tired, who have pains in the midst of blooming health, who are finicky about their food, who have bursts of anger, who cannot keep their sexual life within anything resembling natural bounds. They are variously labelled neurotics, hypochondriacs, victims of psychoneurosis.

Certain of them have gone to physicians always. Here a curious situation arises. The physician usually recognizes the fact that their troubles, whatever their nature, have no physical basis. Most physicians become somewhat irritated at the idea of a person in good bodily health taking up the time of people who could be treating the actually sick. This irritation is communicated to the patient, who resents both the attitude of mind which makes light of his complaint and the fact that the physician is irritated on that score. Almost invariably these people do not get on with regular doctors. They go from one to the other and finally fall into the hands of quacks or semi-quacks. They are the ones who do ninety per cent of the complaining about doctors.

Since the beginning of time, religious cults, healers, queer doctrines have flourished for just this group. Within the modern era Mesmer was one of the first to supply a natural rather than a physical explanation for the effects of a treatment on neurotics. He believed the old astrological doctrine that the stars influenced men and he identified the influence as electrical — called it "animal magnetism."

Perhaps the best-known religious cult which treats these individuals is Christian Science, using a philosophico-religious method.

With the use of scientific psychology, the medical profession began to study the problem on a rational basis. Especially during the twentieth century have the methods of such men as Charcot, Dejerine, and Janet in France, Weir Mitchell in America, and Freud in Austria been taken up and developed.

Certainly this is one of the major medical advances of the century. While it must be admitted that nothing has been established, that none of the systems are thoroughly satisfactory, that the practitioners of certain of the extreme systems, especially Freudianism and its spawn, are as resentful of criticism as Mesmer was, still the general direction is proper and may be expected to have a useful future.

POSTSCRIPT

THE FUTURE OF MEDICINE

We hear a great deal nowadays about "salvaging civilization." Few are agreed as to how it is to be done, but certainly it is impossible to imagine any civilization in which the discoveries I have attempted to recount will not be incorporated. No matter what sort of banking or economic or social system is established, men are not going on without using the knowledge of the circulation of the blood, of the bacterial cause of infection, of aseptic surgery, of the obstetrical forceps (or some improvement on them), of the action of anæsthetic drugs, of the uses of opium, digitalis, and mercury, of the principles of refraction of the eyes. Whatever else is "salvaged," these certainly will be saved. They will, in the noble phrase of Keats, never pass into nothingness.

What of medicine's future? Scientific prophecies are notoriously dangerous. Benjamin Brodie, you remember, was announcing that men would never find a satisfactory agent for surgical anæsthesia at the very moment that the packet with the news of ether was on the way to England. Samuel Gross said that surgery had reached the limit of its possibilities and he had never removed an appendix. Similar pronouncements have been heard recently from surgeons. They seem to have a way of being pronounced just when a great burst of progress is imminent.

The only safe prediction is that there is no limit to the accomplishments possible.

NOTES AND BIBLIOGRAPHY

In order to preserve what Aristotle and Mr. Vincent Crummles called "the unities" I have followed in this narrative only the main stream of medical progress. Fascinating as all of them are, I have not been beguiled into any accounts of those backwaters and side-streams of error which the river of our art took during the centuries — into the history of quackery, mesmerism, homœopathy, Perkins's tractors, osteopathy, Abramsism, Christian Science, and so forth. Indeed, I have not had space for the inclusion of many solid and substantial contributions which bore legitimate fruit.

Quite deliberately, and after due consideration of the enormity of my offence, I have pitched much of the account, especially the early parts, in fictional form. This because my experience is that the layman does not grasp the significance of the great medical discoveries in the form of straight historical narrative. In extenuation I should like to point out that the words put in the characters' mouths either are extracted from their own writings or are entirely reasonable deductions from those writings of what the character would have said. As Mr. Wyndham Lewis points out in his *Life of Villon*, when one finds in manuscript the words: "the bell rang," it is the historian's privilege to assume that this was accomplished by the agency of human hands, and, therefore, to write: "The sexton rang the bell" does no great violence to historical veracity. I am aware also that I have been somewhat partial to the apocrypha of medical history, but it is not impossible that the apocrypha are truer than the canon. However, in order to make a full, perfect, and sufficient oblation and satisfaction for all my sins, I have indicated in these notes the places where I have wandered without guidance or authority.

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CHAPTER I

" Trepanning or trephining the skull was an operation frequently performed 10,000 years ago in Neolithic times, especially in Western Europe and Bohemia. Evidences of its early practice are also found in Bolivia, Peru, North America, Mexico, and Central America, though none of these latter evidences are of Neolithic age. . . . Broca decided that prehistoric surgical trephining was performed for the relief of certain internal maladies. He suggested that it was performed on young epileptic or mad persons to rid them of the ' genius,' the ' demon,' causing the dreaded symptoms."

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I did not take space to elaborate the theory of mana, which is far more complicated than my passage indicates. The conception of mana is found largely, if not wholly, in the region of the Pacific Ocean. It is, according to Codrington (*The Melanesians;* Oxford, 1891), much like Matthew Arnold's definition of God, " a force altogether distinct from physical power, which acts in all kinds of ways

for good and evil and which is of the greatest advantage to control." Thus, if a man wins in a fight, it is because the mana of a dead warrior possessed him. If the herds thrive or the crops are plentiful, it is because the mana of growth was controlled by the farmer. The opposite of mana is tabu, the negative force of which mana is the positive force. Though they have little to do with actual healing practices, mana and tabu are very primitive forms of religious thought and should be understood in order to grasp the general conception of primitive pathology.

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An extremely learned and now scarce book. It is filled with accounts of all sorts of superstitions, of evil eyes and other human anatomical characters (either deformities, such as squint eyes, or rare traits), and of methods of warding off these influences by hand signs and spitting, etc. Mrs. Bohan, who drew the picture of the evil eye for me, has chosen a harmless and probably kind-hearted old Jew as the possessor and has shown the terror he inspires by the reaction of the populace — invoking the *mano cornuta* gesture. This horned hand is made by extending the index and little fingers, and folding the middle and ring fingers on the palm, clasped by the thumb.

This roughly represents a pair of horns, probably the horned devil in defence. Similar symbols of good luck or defence are horseshoes and mounted horns over the doorway or fireplace of a home.

The career of many eminent persons suggested that they were the (admittedly innocent) carriers of the evil eye. Even a pope. " Ask a Roman about the late Pope's evil eye, and he will answer, 'They say so, and it really seems to be true. If he had not the jettatura it is very odd that everything he blessed made fiasco. We did very well in the campaign against the Austrians in '48; we were winning battle after battle and all was gayety and hope, when suddenly he blessed the cause and everything went to the bad at once. Nothing succeeds with anybody or anything when he wishes well to them. When he went to S. Agnese to hold a great festival down went the floor and the people were all smashed together. Then he visited the Column to the Madonna in the Piazza di Spagna and blessed it and the

workmen. Of course one fell from the scaffold the same day and killed himself. He arranged to meet the King of Naples at Porto d'Anzio, when up came a violent gale and storm that lasted a week. Another arrangement was made and then came the fracas about the ex-Queen of Spain.' "

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The portrait of Peter Chamberlen on page 145 requires some explanation. The historical data about the Chamberlens is very confused. A copy of the "not very rare" engraving here reproduced was presented to the Obstetrical Society of London as the likeness of Peter Chamberlen. But beneath it was written "Paul Chamberlin, 1658." The spelling of the name and the discrepancy between the date and the age of the two people (Paul and Peter) would indicate that the artist had made mistakes in the title. Peter Chamberlen was born in 1601; Paul, his son, in 1635. This would make Paul twenty-three in 1658. The man represented is evidently nearer fifty-seven (Peter's age in 1658) than twenty-three. Paul Chamberlin, or Chamberlen, was Peter's second son and a notorious quack.

The likeness is probably that of Peter Chamberlen, who probably invented the obstetric forceps. All Hugh said was that his father had "attained to" a way. He did not say "invented."

CHAPTER X

Hans Sloane's visit to Sydenham is authenticated. My idea of the conversation is, of course, fanciful. Thomas Dover's presence at the interview is likely, although not absolutely certain.

An Italian student of Galileo's original works tells me that he knows no source for the Cathedral of Pisa chandelier story. But he recounted it himself in a paper on Galileo read before a society of medical history.

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There are several versions of Galvani's discovery of the possibility of electrical stimulus of the muscle and nerve. One is that Lucia herself discovered it while assisting her husband in the laboratory. Another is that an assistant of Galvani touched the muscle with an instrument which had been lying near an electric apparatus; and this is more likely physiologically than my version. But none except the one I give accounts for the presence of the frog's legs.

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